The **Moon** and **Frankenstein's** Origin p. 68

THE ESSENTIAL MAGAZINE OF ASTRONOMY

SKY & TELESCOPE

Sky and Telescope 70 Years 1941–2011

NOVEMBER 2011

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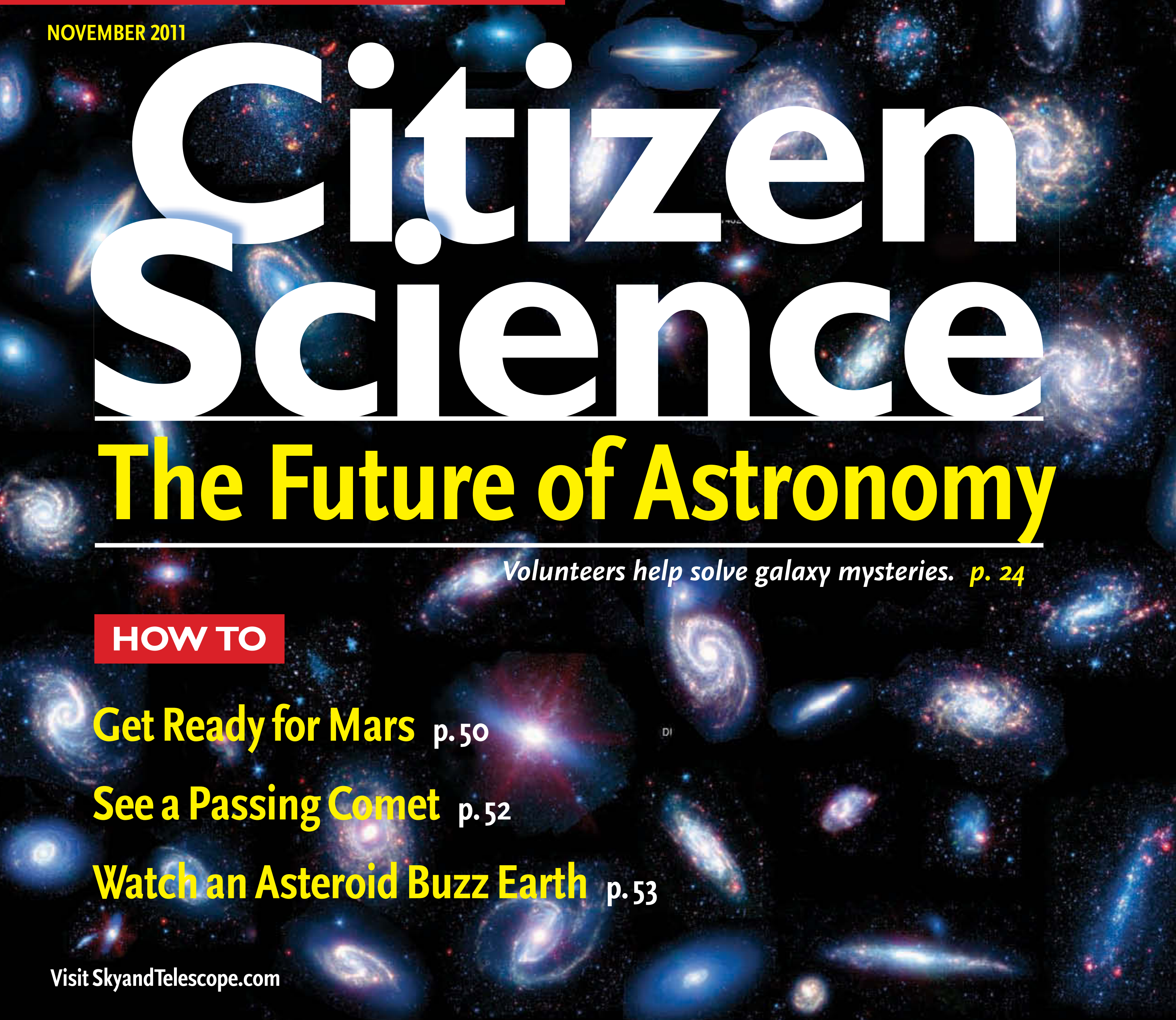

Citizen Science

The Future of Astronomy

Volunteers help solve galaxy mysteries. *p. 24*

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See a Passing Comet p. 52

Watch an Asteroid Buzz Earth p. 53

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November 2011

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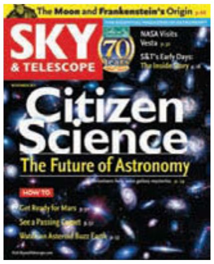

NASA / JPL-CALTECH / KARL GORDON / SINGS TEAM

On the cover: NASA's Spitzer Space Telescope acquired these images as part of the Spitzer Infrared Nearby Galaxies Survey (SINGS).

FEATURES

THIS MONTH'S SKY

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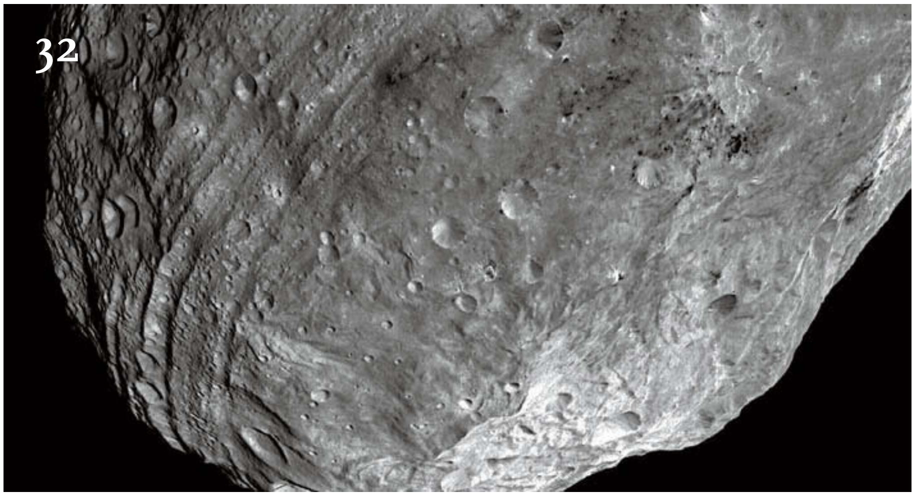
S&T TEST REPORT

ALSO IN THIS ISSUE



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S&T: 70 Years and Counting . . .

In November 1941, on the eve of American entry into the Second World War, two small magazines merged to become *Sky & Telescope*. Under the stewardship of founding editor Charles A. Federer, Jr., *S&T* managed to survive the massive social and economic dislocations of the global conflict and establish a solid foundation for future growth. Thanks to the efforts of Charlie and his small staff, *S&T* proved that a monthly periodical dedicated to a serious, high-minded discussion of astronomy could long endure.

Through subsequent generations, *S&T*'s circulation and stature grew as the magazine gave its tens of thousands of readers in-depth coverage of new technologies and techniques that brought amateur astronomy to increasing numbers of people, and as the Space Age advanced human understanding of the universe by leaps and bounds.

My colleagues and I are excited about *S&T*'s 70th anniversary, but we didn't want to go overboard; our 75th in 2016 will be a much bigger deal. Still, we specifically selected the four feature articles for this issue because they beautifully illustrate what *S&T* is all about:

1. We celebrate our past with the article on page 18, written by Charlie Federer's two children, which vividly describes the challenges that Charlie and his wife Helen faced getting this magazine off the ground.
2. Kevin Schawinski's cover story about Galaxy Zoo discusses the intersection of professional astronomers and citizen scientists, a topic that has always been a staple of *S&T* coverage. I'm particularly excited about Galaxy Zoo because its tremendous success has inspired new types of internet-enabled collaborations that allow the masses to actively participate in cutting-edge scientific research.
3. Jim Bell's article on the arrival of NASA's Dawn mission at Vesta continues *S&T*'s tradition of covering developing news stories with substance and depth.
4. And the story on page 68 about the origin of *Frankenstein* fits in with previous articles by Don Olson and his coauthors about using astronomical clues to solve historical mysteries. I know that *S&T* readers love Don's articles, and I thought it would be fun to have this article on newsstands at Halloween.

We're also celebrating *S&T*'s 70th anniversary on the internet. We have produced video interviews with current and past *S&T* editors, which we also combined into a 70th-anniversary video. You can enjoy these short movies by visiting **SkyandTelescope.com/70Years**.

Robert Naeye
Editor in Chief

SKY & TELESCOPE

Founded in 1941 by Charles A. Federer, Jr. and Helen Spence Federer

The Essential Magazine of Astronomy

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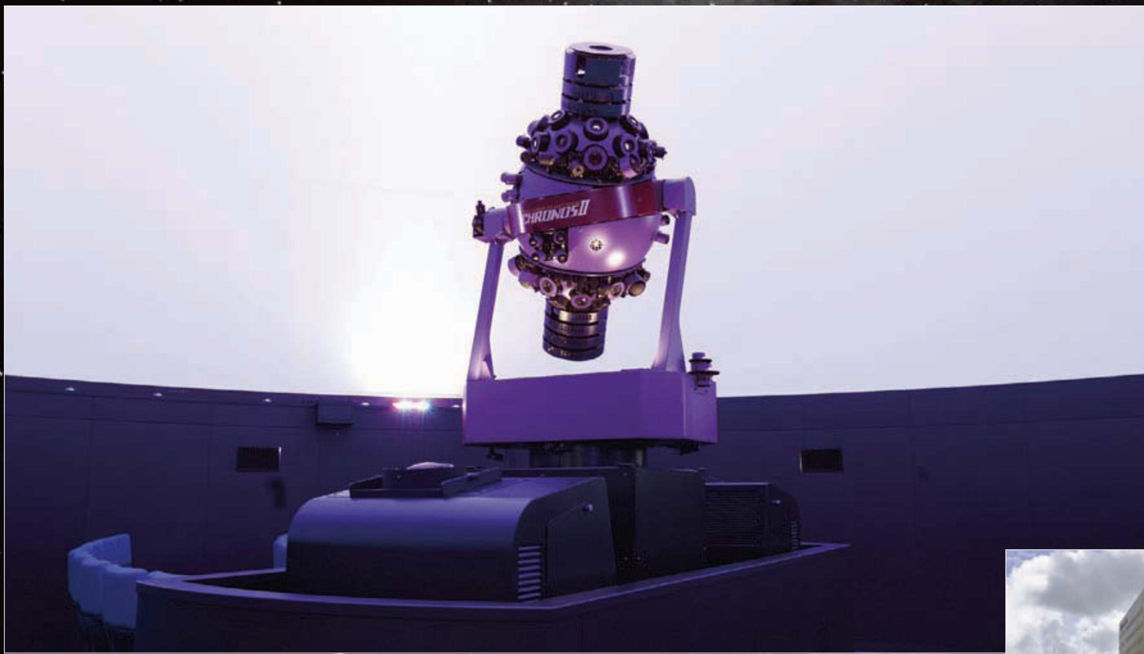
GOTO

New Stars for Okinawa



The capitol city of the Japanese island prefecture of Okinawa is Naha. The city has used a GOTO planetarium since 1966. For more than 4 decades it was located in the Okinawa Youth Hall, which became the Kumoji Public Hall in 1979. But in 2011, these functions were moved into the Makishi monorail station in Naha, where a brand new GOTO CHRONOS II HYBRID has been installed.

Now named the Hoshizora (starry sky) Citizen's Hall, this 12 meter dome takes 84 visitors per program on exciting and educational voyages into the Universe. With the retirement of Japan's last operating GOTO Model M-1 projector, the new facility chose to once again work with GOTO INC to install a state of the art CHRONOS II planetarium projector.

The CHRONOS II uses 100% LED illumination to bring forth a brilliant sky of 8,500 stars to magnitude 6.5, as well as a subtle and beautiful Milky Way made up of 10 million micro-stars. Twin, center-mounted GOTO SP2-HD video projectors also send colorful, dynamic, animated images onto the dome. And the unique GOTO HYBRID Planetarium™ control system accurately locks the moving opto-mechanical and fulldome video images together to make a perfectly synchronized sky scene.

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Light-Pollution Etiquette

I'm of the generation that grew up captivated by the Apollo Space Program, and I also had the good fortune of kind, patient mentors who guided me and instilled in me a passion for the dark skies that I will never lose. I recently brought a young couple to a local star party of several hundred people in Southern California for a promising evening of pleasant company and dark skies. I hoped the event would instill a similar passion in them that would last a lifetime.

As twilight dimmed, and the first stars began to appear, the random satellite passed, and meteor streaked, I relished in the chorus of oohs and aahs. I felt excitement, a sense of community, and that certain *something* stirring my soul. As is the case with such a large gathering, headlights, tail-lights, and flashlights will randomly illuminate the grounds; I advised my two guests to avert their eyes to preserve their night vision and to be careful with their flashlights to avoid offending others.

Sadly, as these unavoidable incidents occurred, "seasoned" amateurs evoked language that would make R. Lee Ermey blush! Though not excusing them, I struggled to explain and apologize to my guests for their passion. Later in the evening, after advising my friends in the safe and proper use of a laser pointer, I was indicating M31 as the farthest object one can see with the naked eye and was confronted by two men telling me (in no uncertain graphic terms worthy of a biker bar) not to use it again, as I was spoiling their deep-sky imaging!

Aside from the irony, or rather hypocrisy, that half the telescopes there had laser pointers, what serious deep-sky imager would hazard their precious images in such a gathering? While I diffused the situation, the damage was done. I fear this couple thinks amateur astronomers are a bunch of jerks, if not worse!

While I share a passion for the dark skies with the majority of amateurs, I fear our community will become insular and loathsome if we tolerate such behavior. While confrontation is not in the spirit of our passion, we cannot tolerate such language and attitudes. If we wish our passion to be passed on to the next generation, we must embrace the inquisitive youth and dismiss such antisocial behavior. We share a precious experience. We have an obligation to pass it on with passion, patience, and grace. I profoundly hope others share my sympathies.

Mikko Nasila
Arcadia, California

I read Bob Parks' interesting article in the September issue about the struggle to control light pollution ("The Battle to Control Light Pollution," page 30). I live in Northern Italy, near Brescia in Lombardy, a very light-polluted area. Unfortunately, Italy does not have a national law against light pollution; we only have a few regional laws, often neglected, that govern only public illumination. My local association, Gruppo Astrofili Deep Sky (**www.bresciaraduno.it**), is on the front lines for this battle.

GAD's latest challenge is the creation of a network of "light-pollution monitors" using SQM-LE meters from Unihedron: we call it the SQM-Network. We can read SQM values every 60 seconds both from our internet server (if SQM-LE apparatus is connected to the internet) or using custom-made software called GECO that we distribute for free.

Using GECO it is possible to read and store SQM data offline, rather than upload all the data on our internet server when the connection is available. All the collected data are freely available on our website (**www.sqm-network.com**).

Both the site and GECO are in Italian, but we are working hard to translate it into English in order to widen the SQM-Network to the rest of the World; at the moment we have four international stations in Canada, Norway, Spain, and Mexico.

If you wish to be a part of the SQM-Network, please e-mail us anytime at info@sqm-network.com.

Edoardo Radice
Lombardy, Italy

Write to Letters to the Editor, *Sky & Telescope*, 90 Sherman St., Cambridge, MA 02140-3264, or send e-mail to letters@SkyandTelescope.com. Please limit your comments to 250 words.

Van De Kamp's Groundwork

I read with great interest Brandon Tingley's article, "The Exoplanets That Weren't" (August issue, page 28). I grew up in Swarthmore, Pennsylvania, during the 1960s, not as a student at Swarthmore College, but as a teenager in the town of Swarthmore. And I can tell you that Peter van de Kamp's "discoveries" of extrasolar planets at Sproul Observatory electrified my friends, my family, and me, and made our entire community proud.

At a time when *Star Trek*, *The Outer Limits*, the Apollo program, and constant news reports about UFOs embodied the Space Age zeitgeist, van de Kamp's discoveries gave us our very own hometown space hero. People talked about Barnard's Star B in school. My 10-year-old brother wrote a 10-page story, *First Men on Cygni 61*, based on one of van de Kamp's earliest planetary "discoveries." My friends, my brothers, and I speculated that the nationwide rash of UFO sightings was attributable to an alien civilization on one of the Barnardian worlds. And when, at the age of 15 in 1969, I sent a query letter to the staff of Sproul Observatory concerning all the exoplanet "discoveries," I was thrilled to receive a handwritten response from van de Kamp himself, a detailed two-page letter I will forever cherish.

Like van de Kamp's professional associates, we were at first incredulous, then devastated, to learn that all his discoveries were erroneous. It was an object lesson for us to never stop questioning, even something as convincing and enthralling as the Sproul Observatory's purported planets. We take some comfort, as Brandon Tingley notes, that van de Kamp's flawed work did lay some groundwork for future true exoplanet discoveries. Personally, I will always look back fondly on how van de Kamp's research thrilled my childhood hometown, and turbocharged my adolescent imagination with distant planets that seemed real enough to touch.

John Rounds
Hoboken, New Jersey

For the Record

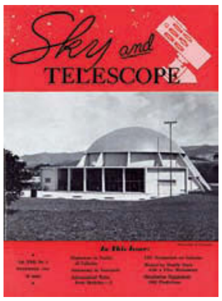
✹ *The article "Beyond the Familiar Veil" used red for the highlighted objects, making it unreadable if using a red flashlight at night (September issue, page 60). A revised version is available as a PDF file at* ***SkyandTelescope.com/BeyondVeil****.*

75, 50 & 25 Years Ago

Roger W. Sinnott

November 1936
New Magazine "With this issue, *The Sky* makes its initial appearance among the popular scientific publications. It succeeds *The Drama of the Skies* as the official publication of the Hayden Planetarium."

Under the full title The Sky — Magazine of Cosmic News, *the new monthly listed Charles A. Federer, Jr., as staff assistant. Five years later, Federer and his wife, Helen, would found* Sky & Telescope.



November 1961
Solar System's Birth "R. A. Lyttleton of Cambridge University, England, proposes that the sun captured interstellar gas and dust, which gave rise to a suitable planet-forming disk."

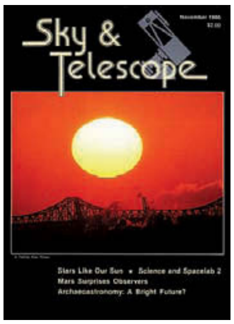
"The English mathematician [calculates that this] capture would be possible if the velocity of the sun relative to the cloud were as low as 0.2 kilometer per second. . . . Very little of the accreted material would be added to the body of the sun, almost all going into orbit around it.

"Generally speaking, the motions of interstellar clouds relative to the sun are much faster than the 0.2 kilometer per second required by Dr. Lyttleton's hypothesis."

In showing that unusual conditions were needed, Lyttleton was tolling the death knell of his own theory. Today astronomers regard planets as the natural result of star formation. The recent upsurge in exoplanet discoveries isn't so surprising.

November 1986
A Serious Discipline? "Archaeoastronomy is as much about human behavior as astronomy. And thus we need to look far beyond the measurements and statistics spewed out by the computer, to develop ideas and explanations that have more meaning for the ancients than for us."

In his assessment of the past, present, and future of archaeoastronomy, Anthony F. Aveni was reacting to the dubious celestial alignments being claimed for Stonehenge and the Peruvian Nazca lines.



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A Planet Blacker than the Blackest Coal

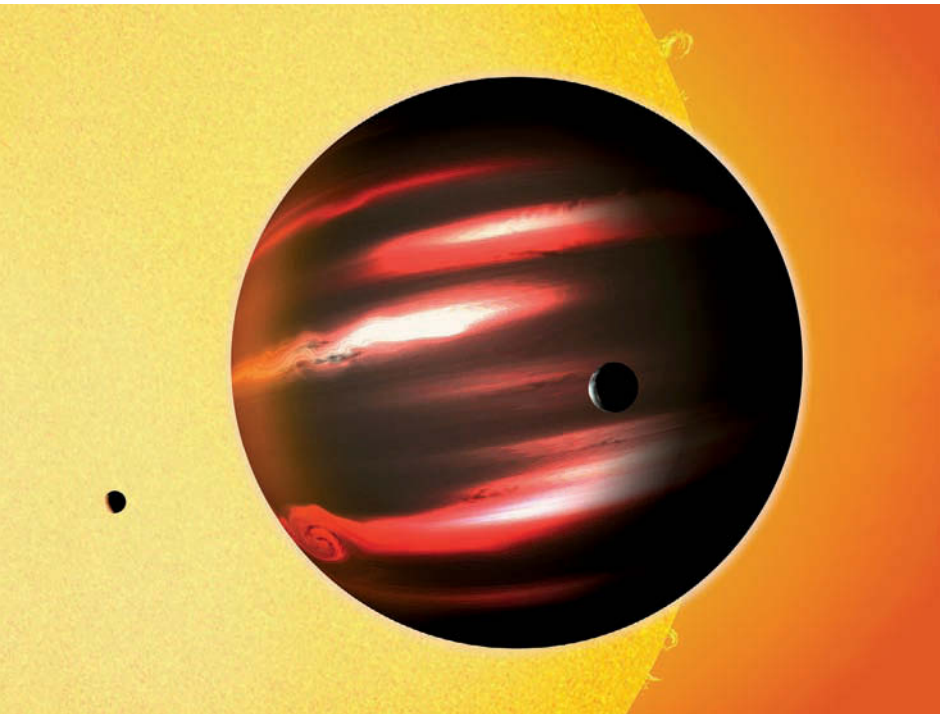
Exoplanets keep coming in ever more alien varieties. The latest is a hot giant that's darker than powdered charcoal.

The planet, TrES-2b, closely orbits an 11th-magnitude Sun-like star 700 light-years away in Draco. Speeding around just 3 million miles from the star, the planet is so brilliantly illuminated that it should be hotter than 1,800°F (1,000°C).

David Kipping (Harvard-Smithsonian Center for Astrophysics) and David Spiegel (Princeton University) used precision photometry from NASA's Kepler mission to tease out the planet's reflected light from the system's total light, when the planet orbits around to the far side of the star and shows us its full lit face. They found that the planet reflects less than 1% of the light hitting it — making it blacker than any ordinary substance on Earth.

Astronomers had already found that some, but not all, "hot Jupiters" are quite dark, as might be expected from the black dust that ought to condense high in their broiling atmospheres. But no one knows why TrES-2b is so *extraordinarily* dark. "We can't, as of now, identify the molecular species that's responsible for this absorption," says Spiegel.

"This discovery is less about something completely new," comments planetary scientist Sara Seager (MIT), "and more about adding to the growing evidence that a class of hot Jupiters is indeed very dark."



DAVID A. AGUILAR / CFA

The hot planet TrES-2b (artist's concept) is darker than the blackest coal, with an albedo (reflectivity) of less than 1% overall. The two moons are the artist's added touch; there's no evidence yet for moons of any exoplanet, though searches for them are still young.

The red dot is ULAS J1120+0641, an early quasar powered by a black hole with a mass of about 2 billion Suns.

ESO / UKIDSS / SDSS

The Too-Earliest Quasar

How fast did supermassive black holes, and big gatherings of matter in general, clump together in the early universe? Standard cosmology has had a hard time accounting for how quickly some cosmic structures grew, given the extreme smoothness of the Big Bang. Now a new find further pushes the limits.

A European team has discovered a very luminous quasar shining just 770 million years after the Big Bang, at a redshift (z) of 7.085. A quasar is powered by a supermassive black hole swallowing large amounts of surrounding matter. This one has a mass of 2 billion Suns, judging from the brightness and temperature of the hot gas spiraling into it.

The team, led by Daniel Mortlock and Stephen Warren (Imperial College, London), found the quasar in deep infrared sky surveys, then confirmed its nature with spectra taken at the 8.1-meter Gemini North telescope in Hawaii.

Named ULASJ 1120+0641 (for its coordinates in Leo), the quasar is not the farthest object known. Nevertheless it dates from the *reionization epoch:* the end of the cosmic "Dark Ages," when the first stars and quasars lit up and ionized the neutral hydrogen gas that filled the universe after the Big Bang cooled (May issue, page 26). Analysis of the quasar's spectrum shows that its own radiation was ionizing its surrounding space up to 6 million light-years away.

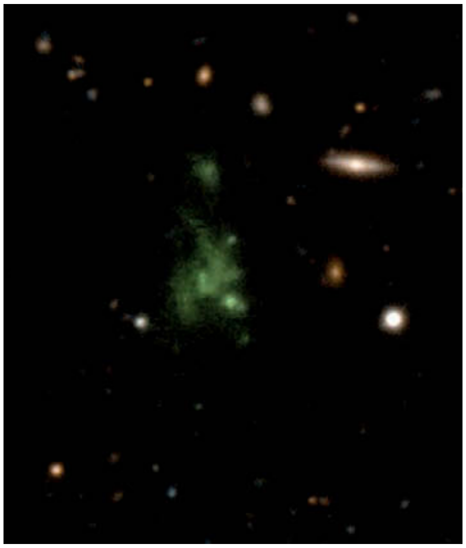
Such a big early black hole "gives astronomers a headache," says Mortlock. "It's like rolling a snowball downhill and suddenly it's grown to 20 feet across."

The Biggest Early Nebula

Some of the early cosmic ionization was powerful enough to make enormous gas clouds glow visibly. Deep searches have located about 32 such supernebulae having up to 10 times the mass of the Milky Way. These "Lyman-alpha blobs" may have originated during the reionization epoch (see previous story), but so far none have actually been seen that far back.

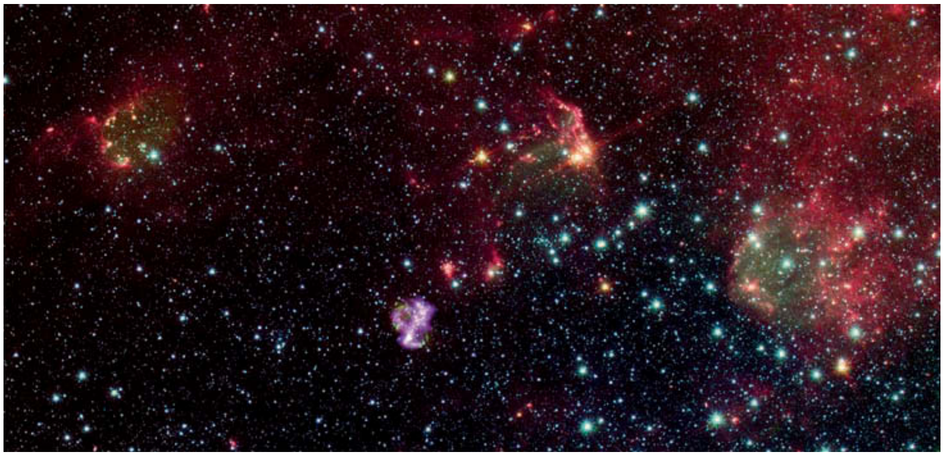
Matthew Hayes (University of Toulouse, France) and others recently studied the largest known Lyman-alpha blob, named LAB1. It's 300,000 light-years across and located at redshift 3.1 (cosmic age 2.1 billion years). The team found that its light is polarized in a radial pattern — suggesting that the gas is scattering light from unseen galaxies hidden within it.

These galaxies must be extremely rich in ultraviolet-bright young stars to ionize so much gas so far away and make it fluoresce. Such intense nests of star formation are quite rare in the present-day universe. The Lyman-alpha blobs give astronomers a look at processes in the early cosmos that are now largely extinct.



ESO / M. HAYES

LAB-1 (green blob) as seen by one of the 8.2-meter Very Large Telescope reflectors in Chile. This is a composite of two images: a wide view showing the surrounding sky (with foreground objects) and a much deeper observation of the hydrogen cloud itself, made to detect its internal polarization.



X-RAY: NASA / CXC / PENN STATE / S. PARK / J. LEE. INFRARED: NASA / JPL-CALTECH

The supernova remnant SNR 0104 in the Small Magellanic Cloud is thought to be the debris from a Type Ia blast. The expanding remnant emits strongly in X-rays, shown purple here. Red and green represent two infrared wavelengths from unrelated stars and nebulae.

The Cause of Type Ia Supernovae

Type Ia supernovae are intensely valuable to astronomy because they're the best and brightest "standard candles" for telling the distances of far galaxies without relying on redshifts. Type Ia's explode with a narrow range of luminosities, and each one's place in this range can be told accurately by its rate of fading. Clearly, almost exactly the same process is happening in them everywhere. So it would be nice to know exactly what that is.

The general picture is clear: a Type Ia happens when a carbon-oxygen white dwarf star collects just enough mass from a binary companion to approach 1.4 solar masses (the Chandrasekhar limit), where it starts to collapse in on itself. In just seconds, the growing pressure at its center sets off a runaway thermonuclear reaction that fuses almost all of the 1.4 solar masses of carbon and oxygen into heavier elements, releasing a well-calibrated amount of energy.

A competing theory is that the tip-over happens when *two* white dwarfs spiral together and merge. This scenario would add troubling uncertainty to how much mass is involved and how much energy these explosions release.

Score one for the standard model. A team led by Assaf Sternberg and Avishay Gal-Yam (Weizmann Institute of Science, Israel) finds that an ordinary mass-donor star must indeed be present in the system, at least some of the time.

The ordinary star, up until the white dwarf explodes, would be blowing off at least a thin stellar wind. A pair of white dwarfs would not do this. Examining spectra of 35 Type Ia supernovae in relatively nearby galaxies, the team found sodium (which has strong, easily detectable spectral lines) in the expanding debris of some of the blasts. Sodium should not exist in a white dwarf, nor should it be created in the explosion itself. It's apparently in the swept-up stellar wind from a normal star that was in the system beforehand.

Not all supernova specialists are convinced. "I suspect the results are also marginally consistent with zero," says Robert Kirshner (Harvard-Smithsonian Center for Astrophysics). "This is not the fault of the observers — they have a sound approach. Basically, they need to build up the statistics."

The *quite* nearby Type Ia that exploded in M101 on August 24th should help.

To get astronomy news as it breaks, visit SkyandTelescope.com/newsblog.

PBS / WCET

PBS / NOVA

Left: **Big shoes to fill; Carl Sagan in a publicity photo for the original *Cosmos* series.** ***Right:*** **Neil deGrasse Tyson will host the new *Cosmos*.**

The Return of *Cosmos*

Back in 1978–79, Cornell astronomer Carl Sagan teamed up with public television's KCET to produce 13 hours of prime-time programming about astronomy and our place in space and time. *Cosmos* aired in 1980 and it became the Public Broadcast System's most successful show ever. Still available on Hulu, YouTube, and DVD (with updates), it's been seen by an estimated 700 million people worldwide, equal to one-tenth of the world's present population. But much of it is more than 30 years out of date.

Sagan died in 1996. But now a new *Cosmos* is in the works. It's the vision of his widow and coauthor Ann Druyan and her Cosmos Studios. She'll again be aided by astronomer Steven Soter, a key collaborator for the original. The new producer, Seth MacFarlane, helped to sell the show to Fox TV. Thirteen episodes of *Cosmos: A Space-Time Odyssey* will begin airing in 2013.

This time the show will be hosted by astrophysicist and author Neil deGrasse Tyson, director of the Hayden Planetarium in New York and host of the PBS series *Nova Science Now*. Tyson met Sagan as a youth considering where to go to college; Sagan gave the wide-eyed teenager a personal tour of his lab. In later years Tyson has been unabashedly trying to fill Sagan's big empty shoes in educating the public about astronomy.

But TV has changed a lot in 30 years. Druyan and MacFarlane promise to "take viewers to other worlds and travel across the universe for a vision of the cosmos on the grandest scale," presenting scientific concepts with "stunning clarity, uniting skepticism and wonder, and weaving rigorous science with the emotional and spiritual into a transcendent experience." That's a tall order in this new age of in-your-face synthetic video, seconds-long sound bites, and fleeting attention spans. A test of their success will be whether people still marvel at it in another 30 years.

Did a Big Splat Shape the Moon?

Did Earth once have a sizeable second moon that merged with the one that now remains? This could explain the long-standing mystery of why the lunar farside is so different from the nearside, being covered by a thick blanket of bright material and showing few areas of lava flows.

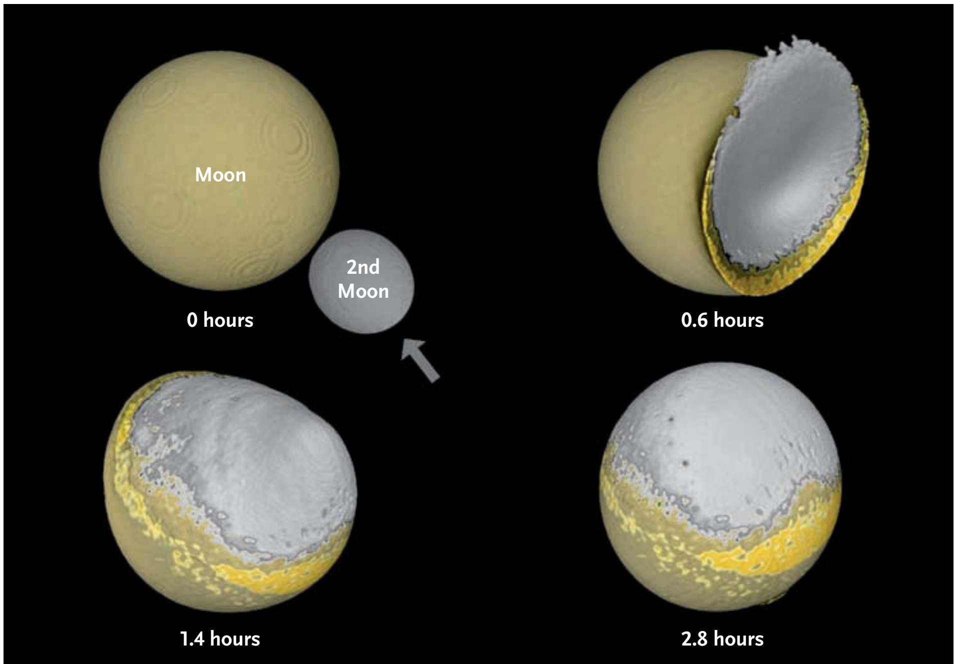
Ever since the first images of the farside came back in 1959, planetary scientists have proposed ways to explain this striking difference — including a spray of material excavated from the enormous South Pole–Aitken Basin, or lopsided churning of magma in the lunar interior.

A new study proposes a different idea. Martin Jutzi (University of Bern) and Erik Asphaug (University of California, Santa Cruz) modeled what would happen if a smaller satellite plowed into the Moon's face early on. If the two had similar orbits, the impact would be relatively low speed and the smaller orb would splat and accrete, rather than explode and scatter.

This scenario arises from today's consensus model that a Mars-sized object collided with the young Earth 4.5 billion years ago, ejecting the matter that would become the Moon — and smaller, short-lived satellites. The infant Moon swept up the smaller objects as it gradually spiraled out to a wider orbit. But one or more satellites could have settled into the stable Trojan points along the Moon's own orbit — and lingered for tens of millions of years before some perturbation nudged them loose.

The big Trojan in Jutzi and Asphaug's simulations was about a third the Moon's diameter and added 4% to its mass, enough to thicken the far-side crust by 30 miles (50 km). Their simulations also suggest that the splat drove molten rock out of the Moon's interior on the other side, accounting for today's near-side maria.

NASA's new GRAIL mission to map the Moon's internal densities may help settle whether this is indeed what happened. ✦

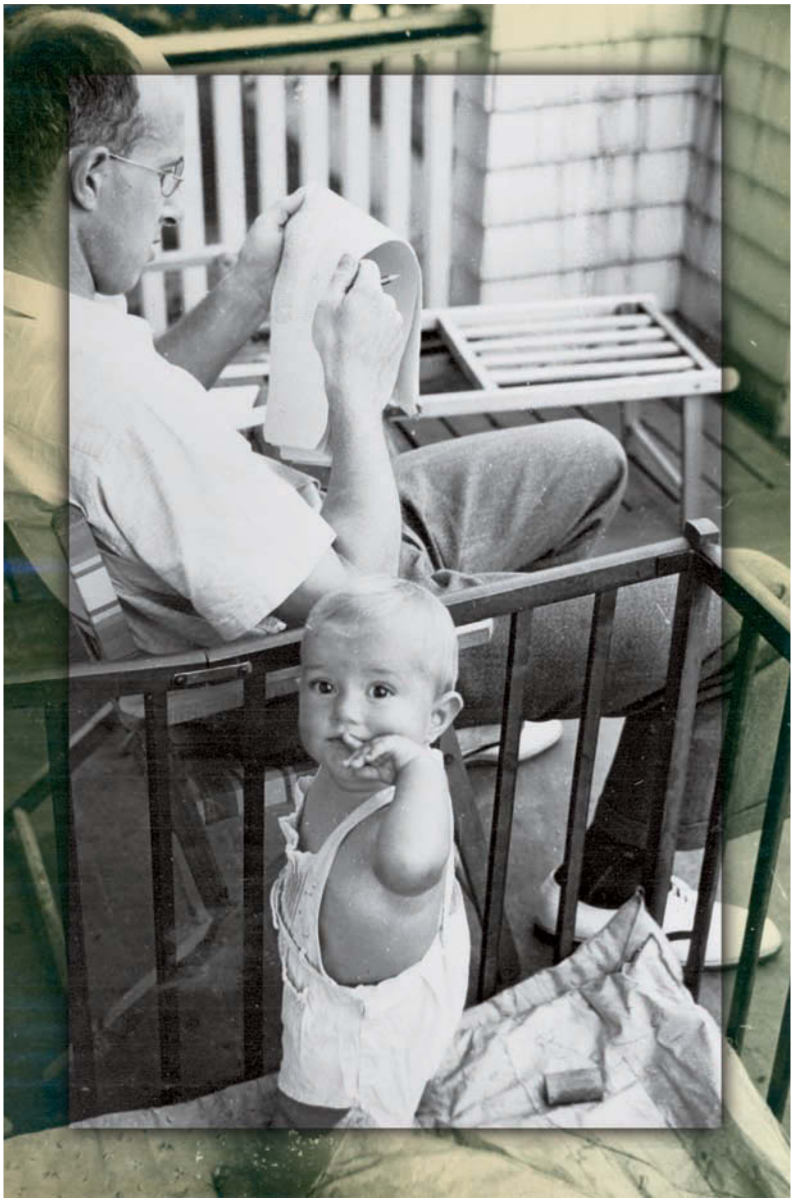


Four frames from a simulated collision between the Moon and a smaller second moon that nearly shared its orbit. Because the pileup happens at relatively low speed, most of the smaller object is accreted as a pancake-shaped layer (shown gray) on one side of the Moon.

M. JUTZI / E. ASPHAUG / *NATURE*

Growing Up with S&T: A Family History

It's no exaggeration to say that this magazine began as a family affair.



Barbara Meredith & C. Anthony Federer

In early October 1941 a husband and wife barely into their 30s drove their Ford convertible from New York City to Boston with a 2-week-old daughter in a basket on the back seat next to her nearly 3-year-old brother. They moved the family into a home in Arlington, Massachusetts, and they moved their tiny company, Sky Publishing, to Harvard College Observatory (HCO), where they quickly produced the inaugural November 1941 issue of *Sky & Telescope*. The parents were Charlie and Helen (Spence) Federer, and the children were the authors of this reminiscence, Barbara and Tony Federer.

For the next 15 years, the magazine and Federer family life were inseparable. An early photograph shows Barbara (known to the family as "Bar") in her playpen next to Charlie with galley proofs in his hand. Few children, then or now, grow up seeing so much of their parents at work. Few children, especially now, were expected to be as independent as we were. And few children, especially then, got to see so much of their country and the world. We were also privileged to be introduced from birth to the concept of equal rights for women, and much of the magazine's early success was due to the drive and energy of our mother, an English major, whose editorial skills complemented the more scientific bent of our father.

The "Magazine"

Wherever we were, at home, on trips, or on holiday breaks, the monthly deadlines were always in control. Even as young children we became involved with the labor-intensive production process of the magazine. Type-

***Sky & Telescope* and the Federer family grew up together. Here Charlie reads galley proofs for the fledgling magazine while watching over daughter Barbara on the family's front porch. Uncredited photographs are courtesy of the authors.**

A family portrait from March 1943 has *S&T*'s founders Charlie and Helen Federer flanking their children Tony (left) and "Bar," who jointly authored this reminiscence about the people, places, and events that helped shape the magazine's early years.

scripts were prepared for the printers and galleys from the linotype machines were proofread. We were often called upon to read the original copy aloud, learning to state all the punctuation marks, so that our parents could mark corrections.

The corrected galleys were cut, arranged, and pinned to layout sheets together with proof images from the engraved "cuts." This was not an easy environment for young children, and there was no room for error in our use of grammar, figures of speech, and spelling. Monthly visits to Adams Press in nearby Lexington often saw us playing outside on the grass or, more exciting, being allowed inside to see and hear the racket of the linotype machines and the rolling presses.

In the basement playroom of our home was a makeshift darkroom, complete with a cardboard blackout panel for the one window. Here we learned to develop film and make contact prints and enlargements as we watched Dad produce photographs for *S&T*. Once a year the playroom table became the accounting office, where our maternal grandmother, Mary Louise Thomas Spence, pored over the company books, making this a three-generation family enterprise.

Playing and Working at HCO

The story of how Harvard astronomer Harlow Shapley talked our parents into coming to HCO and merging *The Sky,* which they produced at the Hayden Planetarium, with *The Telescope,* produced at HCO, has been told in earlier issues of *S&T*.* Shapley provided space for Sky Publishing within the observatory's labyrinth of buildings, including initially a cubbyhole office underneath the stairs leading up to the famous 15-inch refractor.

We grew up with HCO as our playground, exploring its grounds while our parents worked. When *they* played, it was on the HCO tennis court, so we also learned the game. We sledded on the hill below the 15-inch and took regular outings to HCO's Oak Ridge Observatory in the town of Harvard, Massachusetts, where a summer picnic brought the HCO "family" together. We also regularly convened at the Shapley's HCO residence. Here we sang Christmas carols and watched eminent astronomers, such as Bart Bok, assume their regular roles in the annual holiday pageant "We Three Kings."

Harvard astronomers, faculty, staff, and students supported *S&T* in many ways and provided most of our parents' social life. Astronomers Dorrit Hoffleit and Cecilia Payne-Gaposchkin were early examples, in addition to our mother, of why women should be treated as professional equals of men.

We were supervised both as young children and as young workers by *S&T* employees. We remember licking envelopes and stamps by the hundreds for special mailings of the magazine and of other publications, such as *Splendors of the Sky*. This became Tony's first paid job. We also worked with an Addressograph machine, which used playing-card size mimeograph stencils to address envelopes. The stencils had various color markings to indicate subscription expiration dates and other information. Working with these was guaranteed to produce inky fingers.

S&T ARCHIVE

The magazine's first office was located in an alcove beneath the stairs leading up to the dome of Harvard College Observatory's historic 15-inch refractor. The observatory is pictured here in the winter of 1945.

* Major articles appeared in this magazine's November 1986 issue (The Story of "The Sky") and November 1991 issue (How *S&T* Came To Be). Digital copies of all issues of *Sky & Telescope,* as well as *The Sky* and *The Telescope,* can be purchased at SkyandTelescope.com.

Other Work

In spite of deadlines, *S&T* did not require a full month's work to produce, and it certainly did not generate enough income for a young family. During World War II Dad taught astronavigation and meteorology at Harvard and Radcliffe. In the late 1940s he gave planetarium lectures for the start-up Boston Museum of Science. Then, in his own words (from a dictated family history):

> During the Korean War, with Helen holding the *S&T* fort, I took a full time job as head of the Scientific Literature Division of the Air Force Cambridge Research Laboratories... After about a year and a half I resigned and returned full time to *S&T*. Of course, my nights and weekends had been devoted to the magazine, which always came first in the Federer ménage.
>
> In the early 1950s, at the suggestion of David Ludlum and Kenneth Spengler of the American Meteorological Society in Boston, I undertook bi-monthly publication of a small popular journal *Weatherwise*. Dave gathered the articles, I edited them, did the layout and printing supervision. After five years, with *S&T* growing larger, Dave took over the project himself. But I had learned quite a bit about meteorology.

In the mid 1950s, Dad's final extracurricular activity was as editor of the astronomy entries for *Webster's Third International Dictionary*. The already cluttered editorial office in the enclosed sunroom of our house became even more so, with a growing collection of index cards for words to be entered into the dictionary.

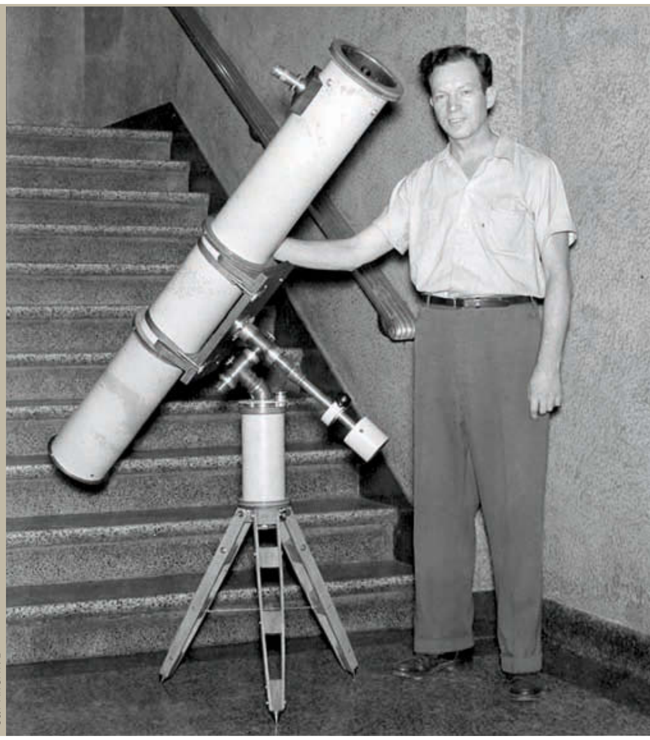
Aptly named Star Trail after the Federers purchased it in the 1940s, this rustic 1850's-era farmhouse in Danbury, New Hampshire, often served as *Sky & Telescope*'s second office when the family spent time there throughout the years.

Star Trail

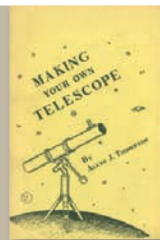
Mom and Dad met in about 1935 in New York City, where they both were working at the Hayden Planetarium. They loved hiking and skiing in New England, so just after World War II they bought an 1850s farm in Danbury, New Hampshire, as a second home and named it "Star Trail" (note the initials). The multiple buildings had no electricity, no insulation, no telephone, and only occasionally running cold water, but we spent many weekends, and

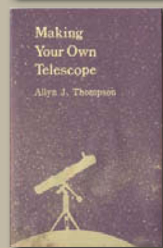
Lasting Legacy

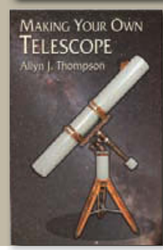
Although difficult to measure, *Sky & Telescope*'s contributions to amateur astronomy have been enormous, especially during the hobby's growth spurt in the years after World War II. For example, New York City postal worker Allyn J. Thompson, pictured here, wrote a series of articles about building his 6-inch reflector that were re-published in book form in 1947. *Making Your Own Telescope* went on to become one of the most influential works in the world of amateur telescope making, and only recently has the book gone out of print.



S&T ARCHIVE







Clockwise from top left: **Travel has always played a major role in *Sky & Telescope*'s editorial content. 1. For the June 1954 total solar eclipse, the Federers escaped cloudy skies with a hasty nighttime drive from the shore of Lake Michigan to Clam Lake, Wisconsin, where Tony's picture captured the diamond ring. 2. His family watches the early morning event. 3. Tony dabbles with eclipse paraphernalia during an expedition to Bredenbury, Saskatchewan, in July 1945. 4. Long-time *S&T* contributor Otto Struve (third from front) joined a Federer hike in Switzerland after an International Astronomical Union meeting there in 1948. 5. During the same trip the family roped together for a more daring ascent to the snow-covered summit of 13,474-foot Mönch when Bar was only 6 years old.**

sometimes weeks at Star Trail throughout the summer and winter.

Our parents often took work to Star Trail, pinning up pages on the big kitchen table as they prepared drinking water by melting snow on the kerosene stove, which, with the fireplace, provided the only heat. When not working we all played canasta by the light of kerosene lamps or listened to records on a hand-cranked Victrola.

Many professional astronomers and Harvard graduate students visited Star Trail, maintaining a family tradition of visitors that began at our grandfather's original country retreat in Branchville, Connecticut, where Bob Cox, of the New York Amateur Telescope Makers (and later a regular *S&T* contributor), had been a frequent guest. Bob's name also appears in the Star Trail logbook.

Travels Far and Near

Trips were (and still are) important for the editors of *S&T*. Our parents traveled to meet with current and prospective *S&T* authors, to encourage the development of amateur astronomy (Dad was a founder and Mom the second president of the Astronomical League), to meet with advertisers, to learn of new discoveries and scientific developments, and to take photos for the magazine. Our childhood memories are marked by our major trips. As children we were brought up to be self-sufficient — some-

S&T ARCHIVE

Charlie frequently attended the annual gathering of telescope makers at Stellafane in Springfield, Vermont. He is seen here addressing the evening program in front of the fabled clubhouse built by Russell W. Porter in the 1920s.

times to an extent that bemused our parents' professional colleagues. In July, 1945, at age 6, Tony was in Bredenbury, Saskatchewan, with our parents for a solar eclipse expedition. He decided to wander away from the eclipse camp and trek two miles into town to find our parents.

In Switzerland for the 1948 meeting of the International Astronomical Union (IAU), there were certainly mutterings when the family roped up to climb to the 13,474-foot summit of the Mönch near the Jungfraujoch, when Bar was only 6! (Earlier that summer we had climbed California's 14,505-foot Mount Whitney.) Shortly after, our family hiked to the Hörnli Hut at the foot of the Matterhorn with long-time *S&T* author Otto Struve.

In 1955 we were at an IAU reception at the home of the President of Ireland, Seán O'Kelly. Bar asked Mrs. O'Kelly's permission to go into the house and wander around while the president and his wife were outside talking to people. Later, in imitation of Dad's role as *S&T* photographer, Bar asked them if she could take their picture, so they said yes and dutifully formed a group.

On the same trip, in England, we joined many others at a formal luncheon at the new Jodrell Bank Transit Radio Telescope, and stopped by the then-soon-to-be new home of the Royal Greenwich Observatory at Herstmonceux.

In the U.S., our travels took us to 47 of the 48 states. One eclipse trip stands out for cliff-hanging adventure; on

Project Moonwatch

During the 1950s *Sky & Telescope* was more than just a chronicler of events leading up to the Space Age. Through a series of special supplements bound into issues beginning in 1956, the magazine provided a vital source of communication among Moonwatch volunteers organized by the Smithsonian Astrophysical Observatory to track the first artificial satellites. Observing teams at Philadelphia's Franklin Institute (*right*) and Fort Worth, Texas (*below*), were among those featured in *S&T*'s Moonwatch coverage.

S&T ARCHIVE (2)

June 30, 1954 we hastily left a campsite (and most of the astronomical community) on the shore of Lake Michigan and made an overnight drive to avoid overcast skies. We arrived at Clam Lake, Wisconsin, just in time for a spectacular (and mosquito-ridden) view of a sunrise total solar eclipse. One of our eclipse photos appeared in the October 1954 issue of *S&T*.

There was usually time for stops at various National Parks and Monuments or for assaults up available peaks or down into canyons and craters. We paid several visits to Mesa Verde, the Grand Canyon, and Arizona's Meteor Crater. Sometimes, however, we had to travel quickly between meetings and back home for the next deadline.

In those days before the interstate highways we'd use the straight-through approach to getting home — Bar navigating for Dad while Mom slept on the back seat and Tony slept on a duffel bag between the seats, then we'd all switch positions. As kids we learned how to read maps, resulting much later in competitive orienteering for both our families. Camping out was frequent on these trips, particularly in National Forests, which led Tony into a career as a U.S. Forest Service scientist. In later years the family had Nash Ramblers in which the seats could be flattened to allow cramped sleep for the whole family in the car.

Trips closer to *S&T*'s home included Stellafane in Vermont after the famed telescope-making convention re-convened in 1954 following an interruption that began during the war years. The programs of that time list not only our father, but also many names in the world of amateur telescope making who were old family friends: Bob Cox, Chet Cook (Bar's piano teacher), Jim Baker, Earle Brown, and Armand Spitz.

Soon after this 1955 picture was taken during a hike to the top of Ben Nevis in Scotland, Tony headed off to college and Charlie and Helen separated, bringing to an end the family collaboration that had seen *S&T* through its critical early years.

The End of an Era

For more than 15 years, we heard many loud, even rancorous debates between our strong-willed and perfectionist parents. They argued long and hard about the magazine and the business, but only rarely about non-business life and the major task of raising children. We were not aware of any separation or hierarchy of responsibilities or decisions, though Mom certainly did buffer and soften Dad's frequent arrogance and rectitude.

Looking back on Dad's strong personality, we have always been amazed at his ability to hire and retain so many long-term employees over so many decades. Perhaps they recognized that he held himself to the same high standard he expected of others — having to publish a correction in the magazine was anathema and very rare.

The stress of partnership took its toll, and by 1955 their close relationship began to break up. Tony was off at college, but Bar lived through the marital and business separation during her last years of high school. The break was gradual and reasonably amicable; our parents weren't officially divorced until 1965. Mom left *S&T* in 1956 and within a year went back to work as Administrative Officer at HCO, from where she retired in 1976.

Other changes came too. Professional astronomer Joe Ashbrook joined *S&T* in 1953, and in the late 1950s the magazine moved to Bay State Road in Cambridge, which became its home for the next half century. The business expanded rapidly, especially with the advent of the Space Age. *S&T* no longer needed the services of its junior editors/mailing operators/general hands, and we were ready to launch ourselves into college and our adult lives. But we always fondly remember growing up with the magazine that was an inseparable part of our family. ✦

***Barbara Meredith** has lived near London, England, since leaving college in 1962. Semi-retired from a varied career in the arts and social sciences, she still raises fruits and vegetables with the skills she learned 60 years ago in the sandy soil of Star Trail. **C. Anthony Federer** continued to live in New Hampshire after Star Trail, and now practices his orienteering skills with a sky chart and his 8-inch reflector named "Charlie."*

Galaxy Zoo and the

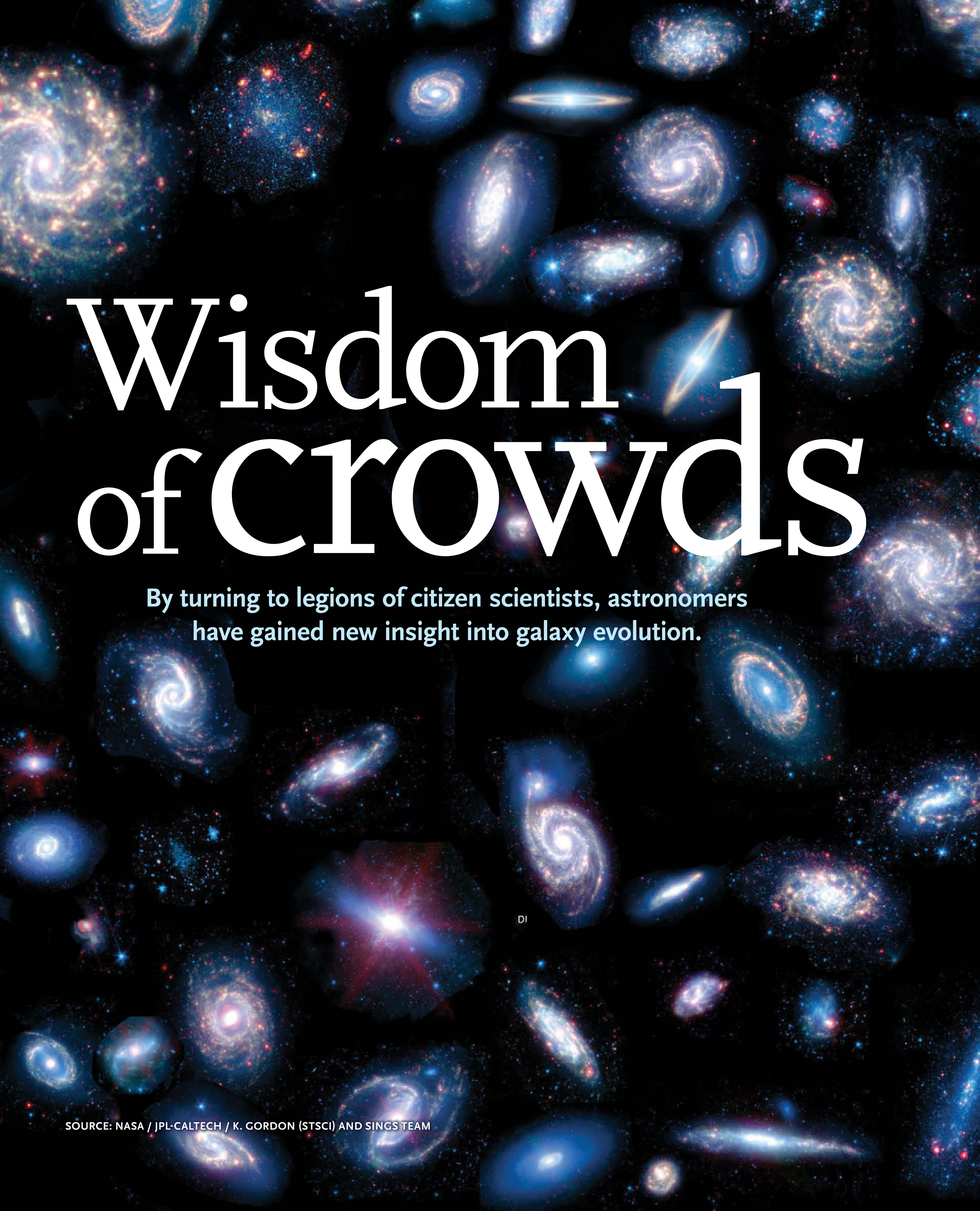
KEVIN SCHAWINSKI

Seeking advice from an expert can be dangerous. Experts may know more about their area than anyone else, but they're still human. How can you tell if they are correct if you're hearing just one opinion? That's why astronomy researchers have been turning to the collective wisdom of crowds on the internet to help answer some of the most compelling questions in modern astrophysics.

One would not want to randomly pluck people off the street to perform open-heart surgery, but in certain cases, the consensus of a group of laymen is more reliable than the opinion of a single expert. For example, fill a jar with jellybeans and ask a Ph.D. engineer to estimate how many beans are inside the container. The engineer might make some brief calculations and add a dose of experience and give you an answer that will probably be way off the mark. But if you turn to a large crowd and ask each person to guess the number, and then take the average, you will probably get much closer to the truth.

SLOAN DIGITAL SKY SURVEY (2)

BASIC GALAXY TYPES These Sloan Digital Sky Survey images show the elliptical galaxy M87 *(left)* and the classic spiral galaxy M101 *(right)*. M101 shines brightly in the predominantly blue light of massive young stars. In contrast, M87 stopped forming stars in appreciable numbers billions of years ago, so its color is dominated by the redder light of old stars.



Wisdom of crowds

By turning to legions of citizen scientists, astronomers have gained new insight into galaxy evolution.

SOURCE: NASA / JPL-CALTECH / K. GORDON (STSCI) AND SINGS TEAM

GALAXY ZOO

GALAXY ANALYSIS Visitors to the Galaxy Zoo website would encounter pages such as this. The Zooite would see a large central frame with a Sloan image of a galaxy, and buttons on the right that would allow the citizen scientist to select a specific galaxy type from several basic categories. Links at the top of the page could take the visitor to any number of related sites, including blogs and forums.

Astronomy has many questions where the nuanced response of a large group of people is very helpful indeed. One major challenge is sorting large galaxies into their basic types — spirals and ellipticals — and then dissecting them into finer classes. Ever since Edwin Hubble first divided galaxies into these two classes, astronomers have wondered how the two relate to each other. Does one type turn into the other? Can galaxies move back and forth as they evolve, or is it a one-way street? For most of the 20th century, astronomers classified galaxies by eye, first into spirals and ellipticals, and then into increasingly elaborate schemes that still color the debate.

With the rise of large-scale surveys such as the Sloan Digital Sky Survey (SDSS), astronomers had to cope with such large numbers of galaxies that classifying them all by eye appeared impossible. They developed new computer algorithms to classify galaxies, but they could never fully reproduce the human ability to tell galaxy classes apart. Even the most sophisticated computer programs trying to mimic the way the brain works would often miss an obvious set of spiral arms and declare a beautiful spiral to be an elliptical. Instead, the computers generally measured "structural parameters" that conveyed useful physical quantities, but they didn't provide the same information as a human classifier.

The Power of the Human Brain

As part of my own graduate research at Yale University, I had classified almost 50,000 galaxy images by eye in search of an evolutionary missing link: a blue elliptical galaxy. Young, massive stars shine brightly in blue wavelengths, so blue is the characteristic color of a galaxy that's still forming stars. But most ellipticals shine red with the light of old stars. The human eye and brain proved to be the most reliable classification tool, but 50,000 galaxies proved to be just scratching the surface. Many of the recent insights in galaxy evolution have come from statistical analyses of hundreds of thousands or even millions of galaxies. To figure out which galaxy properties are important, we needed to group galaxies into categories by characteristics such as mass, environment, star-formation rate, and shape.

Thus the idea of Galaxy Zoo was born in the spring of 2007 at a pub in Oxford, England, as Chris Lintott (Adler Planetarium and Oxford University) and I tried to come up with a better way to classify large numbers of galaxies by eye. We were inspired by the success of the Stardust@home project, which had enlisted the help of people across the internet to hunt for comet dust collected by NASA's Stardust spacecraft. If people were willing to look for dust particles, we thought, perhaps we could persuade them to classify gorgeous images of galaxies.

The Sloan Digital Sky Survey's (SDSS) 2.5-meter robotic telescope in New Mexico had been scanning the skies for years, and it was clear to us that if human eyes could classify the nearly 1 million galaxies it had observed, we could produce exciting new insights into galaxy evolution. After classifying 50,000 SDSS galaxies by myself, I realized that analyzing a million would require a lot of help. Turning to the internet seemed an obvious route, so Chris and I hoped to excite a group large enough that we could classify every one of the million galaxies in a few years.

Things moved quickly and **galaxyzoo.org** went live on July 12, 2007. The start quickly went viral on the internet. The global response was so enthusiastic that the Fermilab servers providing SDSS images soon struggled to keep up and finally crashed when a cable melted. Just a few hours after launch, galaxyzoo.org had died. Fortunately, our col-

JONATHAN SAYERS

BIRTHPLACE OF GALAXY ZOO Author Kevin Schawinski and astronomer Chris Lintott hatched the idea for Galaxy Zoo while downing pints of fine British ale at The Royal Oak, a pub in Oxford, England.

KEVIN SCHAWINSKI

CAROLIN CARDAMORE (X) / SDSS

BLUE ELLIPTICALS The Zooites helped find a crucial "missing link" in galaxy evolution: elliptical galaxies that shine with the predominantly blue light of young stars. Three examples are shown here. Despite the fact that the blue ellipticals unveiled by Galaxy Zoo are relatively low in mass, they may shed light on how their larger red-and-dead cousins formed.

GREEN PEAS Thanks to citizen scientists, the Galaxy Zoo project discovered a new class of compact galaxy whose members shine at greenish wavelengths. These "green peas" are living fossils with no counterparts in our local universe. Exactly how they fit into the overall evolutionary sequence of galaxies remains a mystery.

leagues at the Johns Hopkins University mounted a quick rescue operation and cloned the SDSS SkyServer on some spare machines to cope with the demand.

When we first summarized our goals for Galaxy Zoo, we hoped that each of the 1 million galaxies in the SDSS sample would be viewed and classified once, and estimated that this would take perhaps as many as five years. We were off by orders of magnitude. Within hours, citizen scientists had made 1 million classifications, and the torrent of clicks continued. Just over a year into the project, when we decided that further clicks were no longer improving the results, each galaxy had been viewed *more than 70 times.*

Discoveries

When our international Galaxy Zoo science team had collected enough clicks to start analyzing the results, we turned the user classifications into science while using a blog and forum (**galaxyzooblog.org** and **galaxyzooforum.org**) to interact with the citizen scientists. We considered this crucial because we viewed the citizen scientists as our collaborators who deserved credit for discoveries and to be fully informed with what we did with their hard work. This caused some consternation with academic journals when we inquired whether we would be allowed to submit papers with more than 100,000 coauthors. The journals said our request was unfeasible, so instead each paper links to a web poster where we list everyone who volunteered to have their username made public (**http://zoo1.galaxyzoo.org/Volunteers.aspx**).

By the time we decided that Galaxy Zoo had completed its objectives, we had accumulated enough clicks for every galaxy that we had the consensus vote for each one (survey says: it's a spiral!) and a measurement of how certain the classification was (for example, only 55 out of 70 citizen scientists agree that it's a spiral).

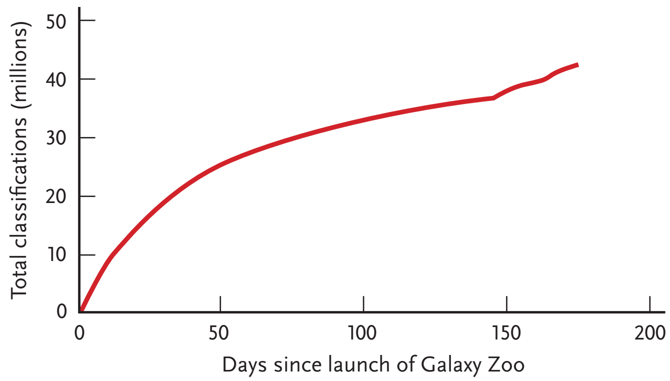
Our main goal was to classify galaxies by shape alone and thus find the odd galaxies that can perhaps teach us the most about galaxy evolution. We quickly found large numbers of galaxies that did not fit the traditional profile of passive red ellipticals and blue star-forming spirals. When spiral galaxies collide, the interaction can destroy their disks, resulting in an elliptical galaxy where all the gas is used up in an intense burst of star formation that produces a "red-and-dead" elliptical. Alternatively, galaxies can slowly exhaust their gas supply or perhaps lose it as they enter galaxy clusters, leading to a more gentle transformation as the spiral arms fade.

Blue ellipticals that are currently forming stars, sometimes at prodigious rates, showed up rapidly in the Galaxy Zoo data and may constitute 5% to 10% of all

TRY YOUR HAND

SDSS / KEVIN SCHAWINSKI

These Sloan Digital Sky Survey images show galaxies that are very easy to categorize as *(top to bottom)* a normal spiral, a barred spiral, and an elliptical galaxy. If you want to try your hand at classifying other galaxies imaged by SDSS, including examples that are less obvious, visit **SkyandTelescope.com/GalaxyZoo**.



S&T: LEAH TISCIONE, SOURCE: CHRIS LINTOTT / GALAXY ZOO

RAPID RISE This graph plots the unanticipated rapid rise in the number of galaxy classifications made by citizen scientists. It took less than two weeks to hit the 1 million mark.

ellipticals, most of which are gas poor and can no longer form stars. But unlike most elliptical galaxies, which are much larger than our Milky Way, none of the blue ellipticals are particularly massive. Since the most massive ellipticals formed in the early universe, perhaps these less massive blue ellipticals are scaled-down versions of those resulting from the processes that formed their massive cousins. Many of these elliptical galaxies show indications of debris and tidal tails, suggesting one or more recent major mergers. Their star formation seems to have come to a rather rapid halt.

Similarly, red spirals abound. While many spirals have a plentiful supply of gas to form stars, these red spiral galaxies no longer appear capable of forming stars. But unlike the elliptical galaxies, the red spirals seem to have experienced a protracted period of declining star formation. As they move from sparse environments to denser ones such as galaxy clusters, they gently slip from active growth by star formation to lower and lower star-formation rates over at least a billion years or so. Dramatic events such as galaxy collisions do not appear to be involved.

The user classifications also helped reveal some surprising results about the galaxies that feed their central supermassive black holes, and those that do not. We asked a simple question: What kind of galaxies feed their central black holes, and does the energy given off by the feeding black hole affect the gas and dust in the host galaxy?

The answer, it turns out, depends on whether the galaxy is a spiral or an elliptical. Ellipticals feed their black holes when they are passing from star formation to quiescence, suggesting that the black hole plays a role in this transformation. In contrast, spirals randomly feed their black hole, and the energy from their black holes does little to change their evolutionary trajectories.

But we were most surprised when we asked what kind of galaxy is most likely to feed its central black hole. It turns out that relatively massive spiral galaxies with rather anemic star-formation rates — in other words, galaxies like our own Milky Way — are the most likely. This is consistent with recent observations by high-energy space telescopes such as INTEGRAL and Suzaku that show that the Milky Way's central black hole was much more active in the very recent past.

Discovering Hanny's Voorwerp

Back in the summer of 2007, not long after the Galaxy Zoo project had gone live, Queen's guitarist and astrophysicist Brian May mentioned it on his website. As a teacher I was on my summer break and was aimlessly surfing the internet when I came across these beautiful pictures. Brian mentioned you could help the astronomers — without being a scientist yourself — by sorting through the galaxies. And so I signed up.

Not even considering myself an amateur astronomer at that time, I read the tutorial carefully and looked at all the examples. Within a week of classifying galaxies I saw a picture on my screen with something I hadn't seen before: a bluish blob near the galaxy IC 2497. Not realizing that nobody had seen such a "thing" before, I asked what it was out of curiosity. But nobody had an answer.

After a year of investigations it became clear I had discovered something new, something rare. Another Zooite had quickly come up with the pet name Hanny's Voorwerp, which stuck even in the scientific papers for which I was invited to be coauthor. The Galaxy Zoo science team made sure that I, and the other Zooites, felt involved in the unraveling of this mystery.

Four years later I have traveled around the world, given interviews to

JOSEPH VONCKEN

THE DISCOVERER Dutch educator Hanny van Arkel became world famous in the astronomy community for discovering the strange "voorwerp" (object) that now bears her name.

Citizen Science

The Galaxy Zoo citizen scientists, or Zooites as they soon called themselves, quickly built a community around the Zoo on our message board. The forum became a place for participants to share their favorite objects, organize their own science projects, and come up with astronomy-related puns.

One project that brought together all of these elements was the search for the "pea galaxies." The Zooites began spotting small, round, and green galaxies that they naturally called "peas." They formed the "peas corps" to give these unusual peas a chance. Upon closer inspection, Yale graduate student Carolin Cardamone, in collaboration with the citizen scientists, discovered that these peas are compact galaxies undergoing very intense bursts of star formation. They are very much unlike any galaxies in the nearby universe. Since the gas being turned into stars in the peas has not been polluted with heavy elements from previous episodes of star formation, they emit powerfully in doubly ionized oxygen, giving them their characteristic greenish color. Because the peas have an uncanny resemblance to galaxies in the early universe, the Zooites discovered living fossils.

A great advantage of humans over computer algorithms is the ability of the brain to spot something unusual or new. So when Zooite Hanny van Arkel, a teacher from the Netherlands, was shown the image of the galaxy IC 2497 and asked to classify it, she instead wondered about a neighboring blue blob (some images show it as green). The blob had been in publicly available data for years, yet it went unrecognized by sophisticated computer programs. She quickly posted a link to the image to the forum where the strange blog was named Hanny's Voorwerp ("object" in Dutch).

To view weblinks for currently active citizen-scientist Zooniverse projects, visit SkyandTelescope.com/GalaxyZoo.

When our team was alerted to this strange object, we made the decision to post as much information as possible on our public blog as we investigated it. Data came in from a variety of telescopes and we simply reported what we saw on our blog. Hanny's Voorwerp turned out to be a large cloud of gas that is fluorescing after being energized by a quasar jet (June issue, page 14).

Citizen science is more than just asking the public to help with science projects; it's also about getting people around the world involved in research and to inspire them to pursue their own interests. On the forum, people with common interests got together to pursue projects and discussions. This involved amazing amounts of self-organization, from people creating their own classification interfaces to citizen scientists organizing their own meetings across the globe. Several citizen scientists were ultimately inspired to take their interests further and return to education.

In the meantime, the citizen scientists told us that what they really wanted was the opportunity to classify

international media, given lectures about the citizen-science project that taught me so much, and I am still involved in the outreach work. I co-moderate the Galaxy Zoo forum, I write and blog, and I show people how they too can participate.

It has been a wonderful experience, and best of all, I get to share what I have learned with a great bunch of people I met through the forum and whom I now consider to be some of my best friends. Needless to say, I'm very grateful to the Galaxy Zoo team.

Hanny van Arkel *lives in Heerlen, the Netherlands, and teaches biology, Dutch, and English at the Citaverde College.*

SDSS

HANNY'S VOORWERP
Hanny van Arkel noticed a strange blue blob in the Sloan image at *left*. The later Hubble Space Telescope image at *right* shows Hanny's Voorwerp in more detail, and with a different color palette in which the blob appears green. Studies using HST and other professional telescopes provide a plausible explanation for the voorwerp: It's a gas cloud fluorescing after being blasted with energy from the active nucleus in the nearby galaxy IC 2497 (above the cloud). The active nucleus has recently shut down, but the blob continues to glow as a light echo. Citizen scientists have since found other voorwerps near galaxies.

NASA / ESA / WILLIAM KEEL / GALAXY ZOO

WILLIAM KEEL (UNIVERSITY OF ALABAMA)

ZOOITES During a meeting in 2009, members of the Galaxy Zoo science team posed with other interested scientists and citizen scientists in front of the Royal Greenwich Observatory in England. Hanny van Arkel is in the front row, wearing a solid green shirt.

galaxies in more detail than just sorting them into a few broad categories. Thus Galaxy Zoo 2 was born, where we asked users a series of questions about each galaxy to investigate features such as the number of arms and bars in spiral galaxies or the presence of dust lanes indicative of recent merger-induced star formation. Work by Karen Masters (University of Portsmouth, England) using Galaxy Zoo 2 results showed that bars are more common in red spirals. It's unclear yet whether the bars are responsible for turning spiral galaxies red, or whether they appear as a consequence of the slow shutdown of star formation.

Struck by the huge numbers of citizen scientists that joined the Zoo, we wondered why so many people around the world volunteered their time. Surveys sent out to users revealed the answer: people got involved because they wanted to actively contribute to research; they wanted to take part in the actual science.

Future

Although Galaxy Zoo 1 and 2 have officially come to an end, the wisdom of the crowd of citizen scientists across the internet has proved to be a powerful new tool in the arsenal of scientists trying to understand the universe. Inspired by the success of the Galaxy Zoo, new projects were born, first in astronomy but then spreading to topics further afield. The immediate successor of Galaxy Zoo is the Hubble Zoo (still at **www.galaxyzoo.org**), where users classify images of galaxies in the early universe taken by the Hubble Space Telescope. Citizen scientists can also explore the plane of the Milky Way Galaxy with the Milky Way Project (**www.milkywayproject.org**) and hunt for planets around other stars at Planethunters (**www.planethunters.org**).

The data flood in the coming decade is going to be one of the great challenges of astronomy. Professional astronomers will need to become proficient database managers and develop sophisticated statistical tools to cope with the output of facilities such as the Large Synoptic Survey Telescope (LSST), which will image the entire sky visible from its location in Chile every three nights. In order to make full use of the torrent of data, professionals will have to turn to citizen scientists for help in exploring it and making discoveries.

Crowd-sourced data mining will be a growing part of astronomy's future, especially after LSST comes online around 2020. I predict these projects will become a major way that new people find out about astronomy as a hobby and learn about science in general. Ultimately, citizen scientists will have to be an integrated part of the scientific process of large facilities, not just in astronomy, but in other fields as well. ✦

Listen to an AUDIO AUTHOR INTERVIEW

NASA / CARLA CIOFFI

To listen to an audio interview with author Kevin Schawinski, visit SkyandTelescope.com/GalaxyZoo.

__Kevin Schawinski__ is an Einstein Fellow at Yale University. He works on the formation of galaxies and supermassive black holes and their coevolution.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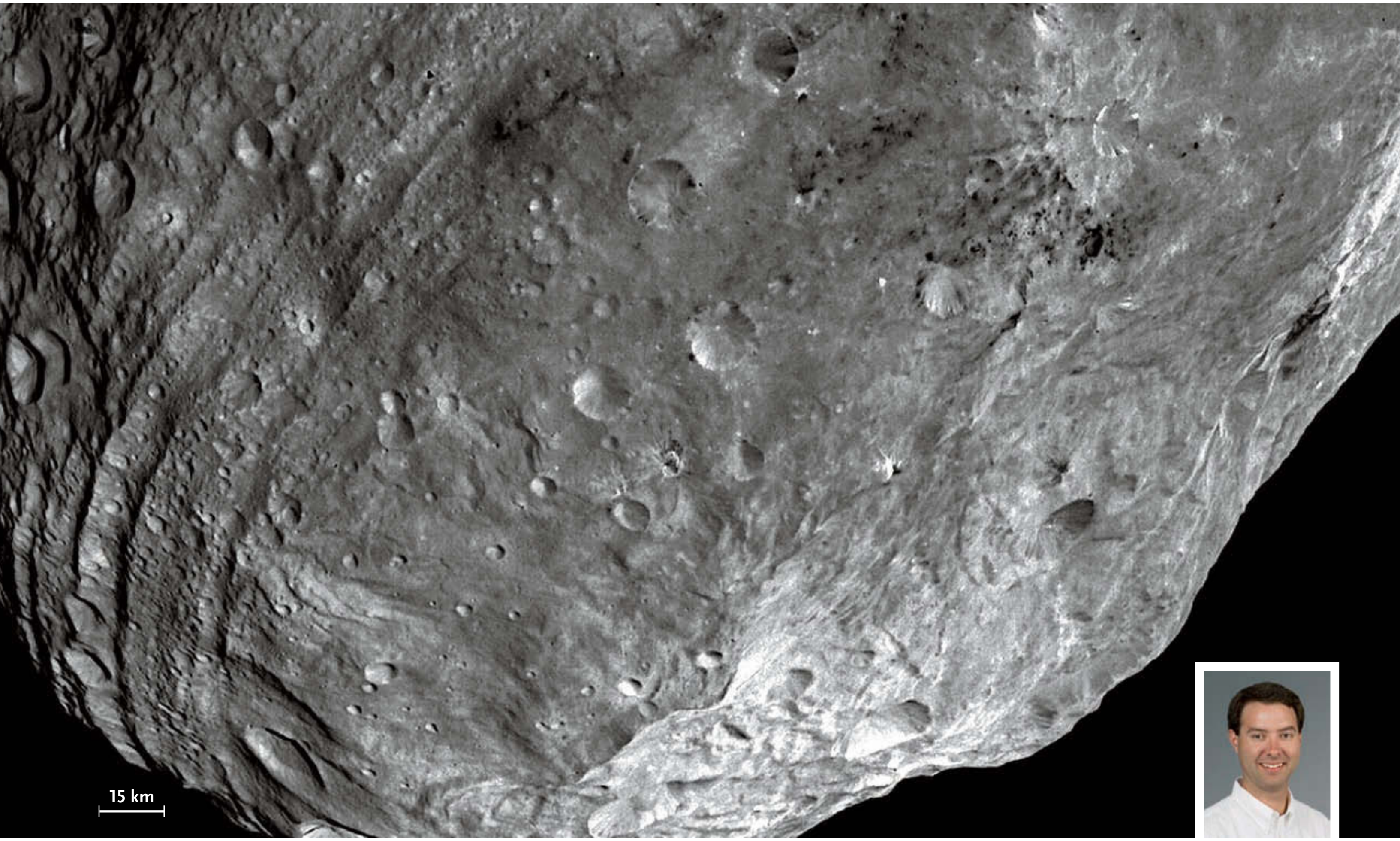

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JIM BELL

Dawn's Early Light: A Vesta Fiesta!

NASA's Dawn mission is giving scientists their first close-up look at a giant asteroid.

WE'VE SEEN OUR SHARE of dramatic mission events over the past few decades of planetary robotic exploration: violent launches on giant rockets, critical main-engine burns, and heart-stopping planetary landings. None of this is routine, and for those of us directly involved in the missions, it's painfully dramatic and gut wrenching.

I felt a normal sense of nervousness and excitement, when, on July 16th, I waited eagerly for the news about NASA's latest critical planetary-mission event — the

SOUTH POLAR REGION Taken on July 24th at a range of 5,200 kilometers (3,200 miles), this image from Dawn's framing camera shows a peak at Vesta's south pole at the lower right. The mountain rises 18 km (11 miles) above the floor of a surrounding crater, and 3 to 5 km above the terrain outside the crater. The equatorial grooves on the left are an astonishing 10 km wide.

capture of its Dawn spacecraft into orbit around the giant asteroid Vesta. This would be humanity's first mission to orbit a main-belt asteroid. From telescopic studies, we knew this Arizona-sized world had an interesting shape and composition, and that it's a possible example of the building blocks from which all the terrestrial planets formed 4.6 billion years ago.

Dawn's capture into Vesta orbit turned out to be anticlimactic. The mission uses a new ion-propulsion technology that, over several years of interplanetary cruise, gently shaped the spacecraft's orbit to nearly match that of Vesta. There was no dramatic main-engine "slam-on-the-brakes" event needed for orbital capture. Rather, as Dawn crept closer, it simply crossed the threshold from being primarily guided by the Sun's gravity to being primarily guided by Vesta's gravity. There was no fanfare, no party, no smiling mission controllers on TV. Still, the event represents a historical milestone — the culmination of more than 200 years of astronomical research and speculation about the nature of minor planets.

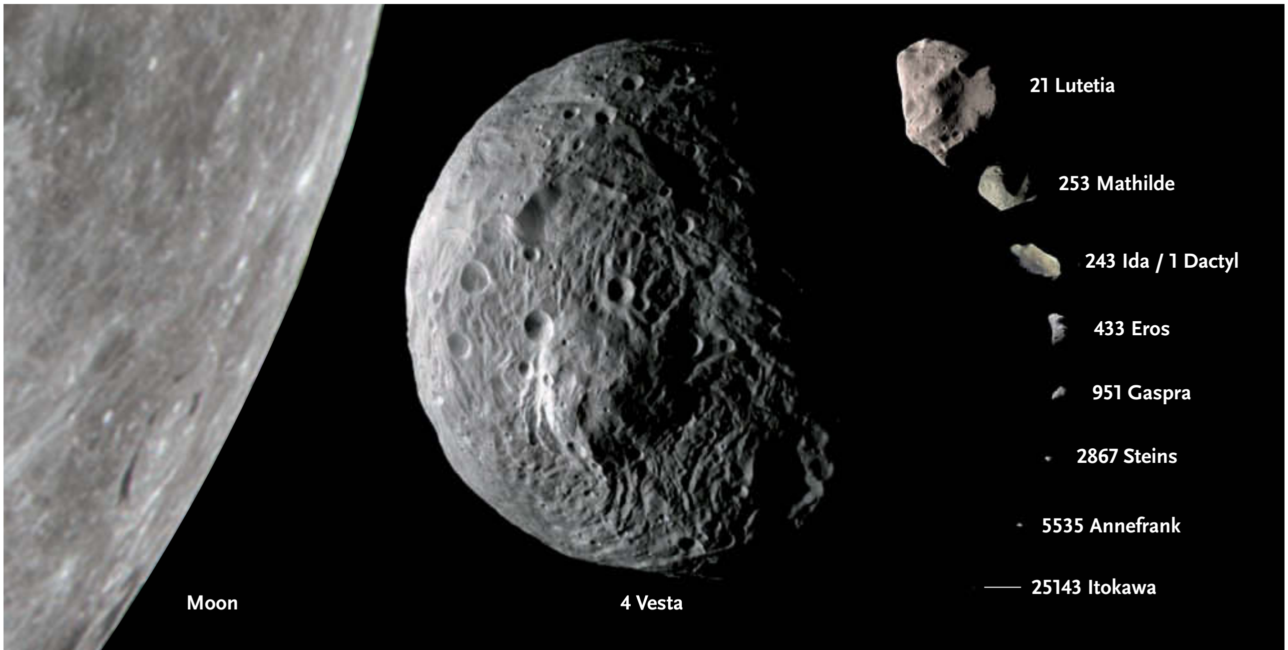
Discovery

Vesta's story as an object of human interest goes back to the early 19th century. Professional astronomer Giuseppe Piazzi discovered the first asteroid, Ceres, on January 1, 1801 as part of his work creating the *Palermo Star Catalogue*, an unprecedented precise survey of more than 7,600 stars. Some astronomers, including professionals and amateurs, thought that Ceres might be the tip of an iceberg of new planets that roamed between Mars and Jupiter.

Among the most capable and meticulous amateurs was Heinrich Wilhelm Matthäus Olbers, by day a physician in Bremen, Germany, but by night the director of his home observatory. Using a modest 3.75-inch achromatic refractor and some of the best star charts, he systematically searched the ecliptic for more of Piazzi's minor planets, and was quickly rewarded for his efforts with the 1802 discovery of the second-known asteroid, which he named Pallas. After German professional astronomer Karl Ludwig Harding bagged the third

S&T PHOTO ARCHIVE

VESTA DISCOVERER Heinrich Olbers (1758–1840) discovered Vesta on March 29, 1807. He is also famous for posing the Olbers paradox: Why is the sky dark at night when there should be a star in every direction?



ASTEROIDS COMPARED This composite image shows the relative sizes of all the asteroids that have been visited by spacecraft. With a diameter of 530 km (330 miles), Vesta is the second largest main-belt asteroid, and it contains almost 10% of the belt's mass. Dactyl and Itokawa are so small they are essentially invisible at this scale.

MOON: DENNIS DI CICCO; ASTEROIDS: NASA / JPL-CALTECH / JAXA / ESA

A CHUNK OF VESTA This 6-cm-wide (2.4-inch), 175-gram (6.2-ounce) eucrite meteorite fell near Millbillillie, Australia, in 1960. Like many dozens of other meteorites, its composition appears to closely match that of Vesta's surface. These rocks might have been blasted off Vesta in the large impact that excavated the asteroid's large south polar crater. These ejected chunks went into orbit around the Sun and eventually fell to Earth.

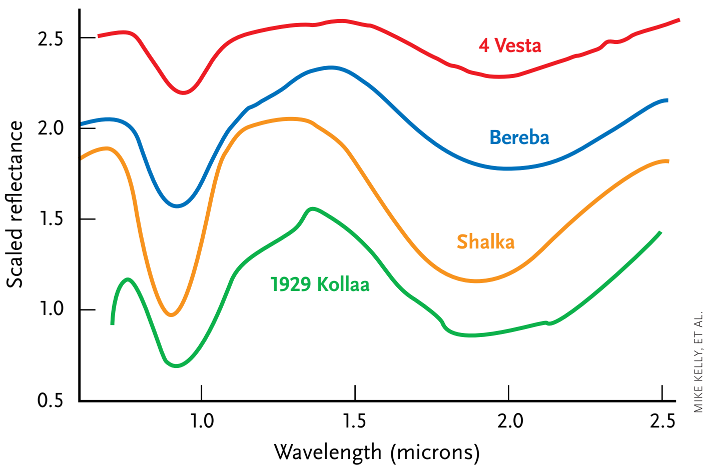
asteroid, Juno, in 1804, Olbers again struck asteroidal gold with his March 29, 1807 discovery of a fourth one. Mathematician Carl Friedrich Gauss helped calculate its orbit and it was he, with Olbers' blessing, who named it Vesta after the Roman virgin goddess of the hearth.

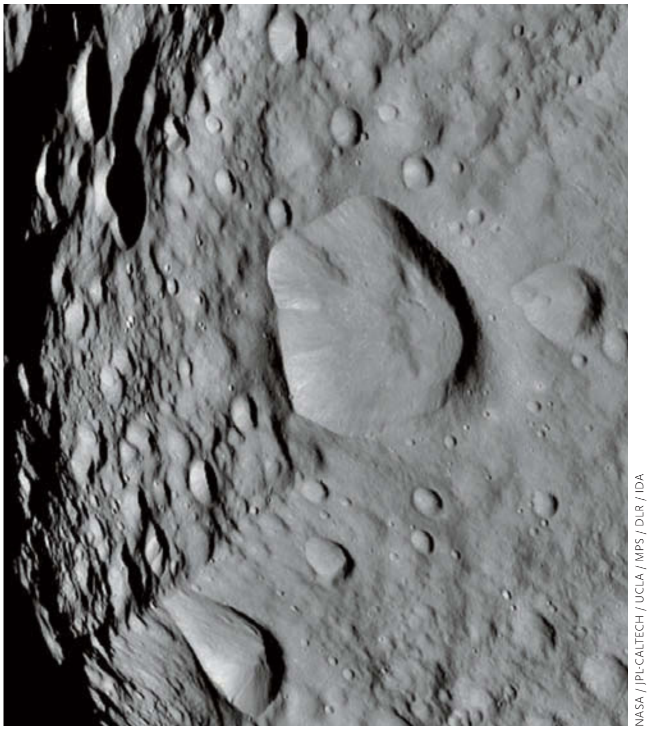
No new asteroids were discovered for nearly four decades, because Ceres, Pallas, Juno, and Vesta turn out to be by far the largest bodies in the main belt. Indeed, we now know that these four bodies comprise about 50% of the main belt's entire mass. It's perhaps no surprise that early-19th-century astronomy textbooks commonly referred to them as "planets." Today, some call them "minor planets" or "dwarf planets" or just "large MBAs" — main-belt asteroids. Some heretics (like me!) even deign to still call them "planets."

A Unique World

Vesta is the brightest MBA, partly because it's one of the largest asteroids, but also partly because its surface intrinsically reflects more sunlight than most other asteroids. That higher *albedo* is also a clue that Vesta's surface composition is different than most other asteroids. Spectroscopic studies over the past several decades have been particularly exciting because they confirm that Vesta's composition is unlike most asteroids. Vesta's surface appears to have the kinds of volcanic rocks and minerals that we find in the crusts and mantles of Earth, the Moon, Venus, and Mars — minerals such as olivine, a common iron- and magnesium-bearing silicate found in deeply formed volcanic rocks.

Vesta's spectra match those of a class of meteorites called the HEDs (for "Howardites, Eucrites, and Diogenites"). These space rocks appear to have formed within the crust or mantle of a large planetesimal and were later violently ejected into interplanetary space during a large impact. Scientists have studied HEDs in great detail in the lab, and their connections to Vesta are strong and well



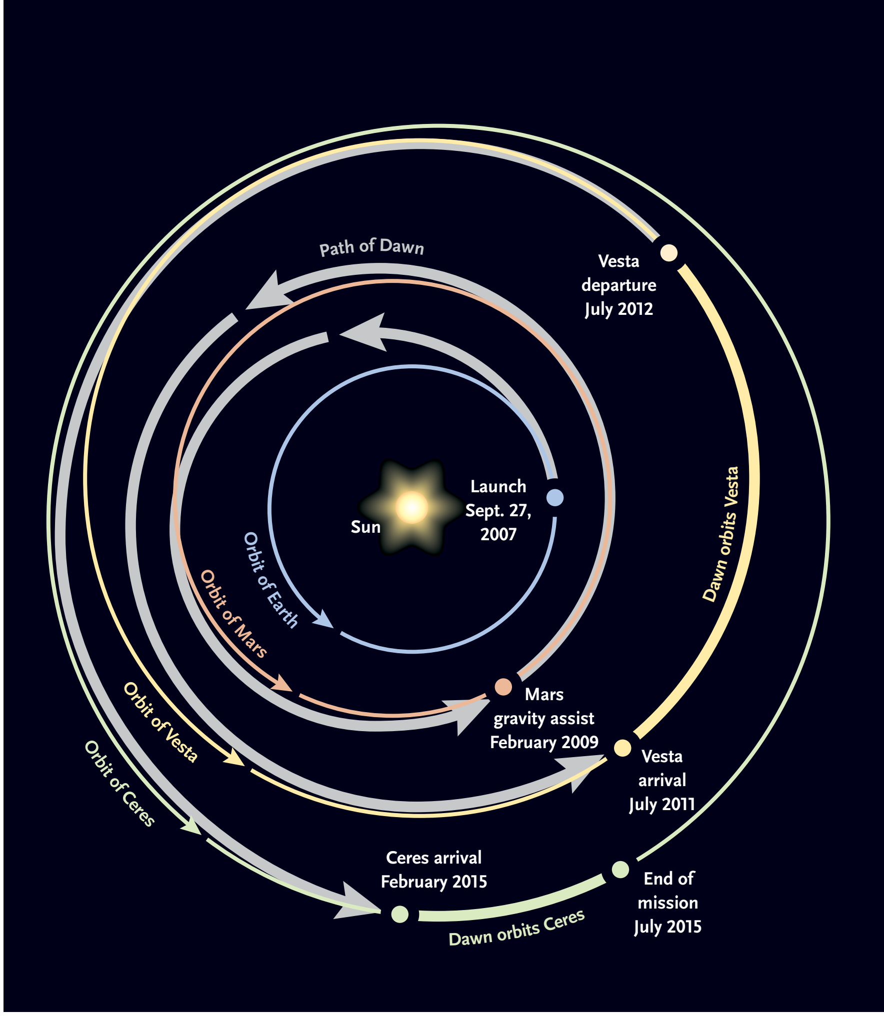


VESTA-LIKE SPECTRA *Above:* Vesta's near-infrared spectrum is compared to the eucrite meteorite Bereba, the diogenite meteorite Shalka, and the Vestoid asteroid 1929 Kollaa. The similar spectra suggest a common origin, probably the latter three objects coming from the giant impact that formed Vesta's south polar crater. *Right*: This August 6th image shows cratered terrain with hills and ridges. Despite the impressive resolution of 260 meters per pixel, images taken from closer orbits will provide much finer detail.

established. If Vesta is indeed the HEDs' parent body, then Vesta must have *differentiated* sometime in its distant past: radioactive elements and other internal heat sources melted the body's interior, enabling it to segregate into a core, mantle, and crust. Because of its rocky composition and likely history of differentiation and volcanism, many planetary scientists refer to Vesta as the "smallest terrestrial planet," despite the fact that the International Astronomical Union has not officially designated it as even a dwarf planet (like Ceres and Pluto).

From ground-based telescopic observations, astronomers have determined that Vesta has a fast rotation rate (only about 5.3 hours), and that it has brighter and darker regions. The Hubble Space Telescope resolved Vesta into a roughly spherical world, with a diameter of about 530 kilometers (330 miles) and a gigantic crater that appears to have been gouged out of the asteroid's south pole. This crater may be the source of the HED meteorites and a population of smaller nearby inner-main-belt asteroids with similar spectra that are often referred to as Vestoids. Astronomers estimated Vesta's mass by the way Mars, Jupiter, and other asteroids perturb its orbital motion. Combined with an estimate of its volume from Hubble imaging, astronomers have calculated that Vesta has a relatively high density of 3.4 grams/cm³, implying a rocky, terrestrial-planet-like nature.

Vesta's size, albedo, composition, and relationships to other asteroids and meteorites all make this world an intriguing and perhaps unique solar-system body, and potentially an important bridge in the continuum of evolution between small planetesimals, protoplanets, and full-fledged terrestrial planets. Planetary scientists have long recognized that Vesta is worthy of up-close exploration. In the late 1990s, a team of scientists and engineers led by principal investigator Chris Russell (UCLA) proposed a mission in NASA's "better, faster, cheaper" Discovery program to orbit first Vesta and then Ceres with an ion-powered spacecraft. The proposal ultimately prevailed against stiff competition, and Dawn was selected for flight.



S&T: GREGG DINDERMAN

DAWN'S INTERPLANETARY CRUISE Using three ion-propulsion thrusters and a gravity assist from Mars, Dawn traveled a curved path 2.78 billion km (18.6 astronomical units) long to reach Vesta. After orbiting Vesta for about one Earth year, it will travel another 1.49 billion km (10 a.u.) for its Ceres rendezvous in February 2015. When it goes into orbit around this second large asteroid, Dawn will become the first spacecraft to orbit two separate deep-space destinations.

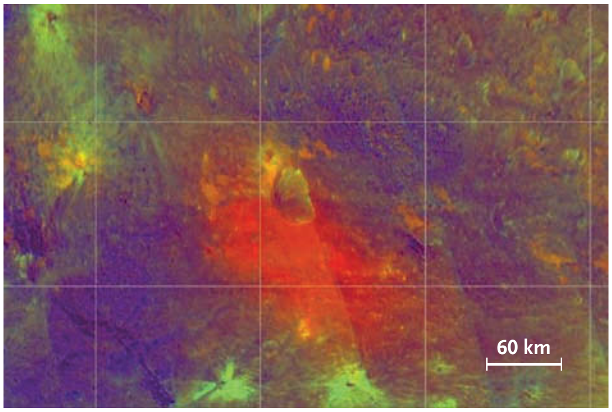
The Mission

Dawn is a quintessential example of a relatively low-cost (about $360 million) spacecraft and instrument package. The mission employs cutting-edge technology, such as the ion engines for propulsion and trajectory maneuvers. But it also uses a lot of tried-and-true technology, such as CCD cameras and spectrometers.

Dawn launched on a Delta II rocket on September 27, 2007, into an outwardly spiraling trajectory that included a February 2009 Mars-gravity-assist boost into the main asteroid belt, and then the Vesta rendezvous in July 2011. Three ion thrusters use electricity generated by the solar panels to accelerate ionized xenon atoms through a rocket nozzle. The ions provide a much gentler thrust than a chemical rocket, but by running the engine over a long period of time, they can produce the same net force with less mass and risk. Dawn's design builds upon two previously successful ion-propelled missions: NASA's Deep Space 1 and the Japan Aerospace Exploration Agency's Hayabusa.

NASA / DAWN

The Dawn team's primary science objectives are to study two large asteroids in order to better understand the conditions under which these planetary building blocks formed, and to clarify the role played by planetesimal size and water content in determining the evolution of Earth and other planets. To achieve these goals, the spacecraft carries a color camera for high-resolution mapping and stereo imaging, a visible to near-infrared spectrometer for mineralogic mapping, and a gamma-ray and neutron spectrometer to determine the abundances of major rock-forming and radioactive elements as well as to search for evidence of water ice or hydrated minerals on the surface. Scientists will also track Dawn's radio signals as the



NASA / JPL-CALTECH / JAXA / ESA

VESTA IN FALSE COLOR Scientists processed this framing camera image in false color to reveal variations in surface composition. The different colors indicate that Vesta is probably not a uniform chunk of rock such as some of the smaller asteroids that have been previously studied up close. Specific details about Vesta's surface composition will have to await further data acquisition and analysis, but scientists already know from earlier telescopic observations that its bulk composition differs considerably from most other asteroids.

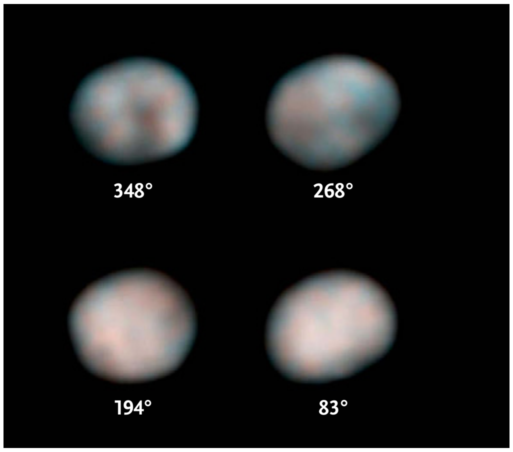
spacecraft orbits Vesta and later Ceres, which will enable the researchers to accurately measure the asteroids' masses and infer details about their internal gravity and structure. Scientists will compare Vesta and Ceres to each other, with major classes of meteorites, and with other terrestrial planets and small bodies.

Since Dawn's gentle capture into Vesta orbit, mission controllers have slowly lowered the orbital altitude to begin a month-long survey orbit phase for initial global geologic and compositional studies. This autumn, they will further lower the spacecraft into a 660-km-high mapping orbit for higher-resolution studies, and then sometime in the winter they will lower it even more, down to a 180-km-high mapping orbit that will last six months. From that altitude, the cameras will resolve features as small as 15 to 20 meters across. The mission design is flexible, so surprising discoveries may lead to changes in the nominal orbit plan in order to maximize the scientific return. The Dawn team plans to raise the orbit to 660 km in late spring 2012 for another round of high-altitude mapping, and then the spacecraft will thrust out of Vesta orbit in July 2012 for a Ceres rendezvous in February 2015.

Initial Results

Dawn's initial results are enticing. Scientists are using images and rotation movies to refine estimates of Vesta's shape and volume, which will enable them to pin down the asteroid's density. As expected for an ancient world, Vesta is heavily cratered, and the crater distribution is enabling scientists to map the relative ages of different parts of the surface. Many craters appear remarkably fresh, with sharp rims and little evidence of erosion, while others appear to have been partially filled in by fine-grained material, perhaps from landslides that also generate dark streaks similar to those seen in several Martian craters.

The enormous south polar crater first seen in Hubble images is turning out to be a fascinating structure, with a dome-shaped interior mountain that might be a giant central peak caused by the impact, or perhaps it's a Vesta-specific volcanic construct. A series of weird ridges and grooves surround the crater and extend widely across the equatorial regions. Some of these ridges and grooves look like enormous slump or landslide features, while others resemble the long grooves seen on various small bodies with giant impact craters, such as Mars's moon Phobos.



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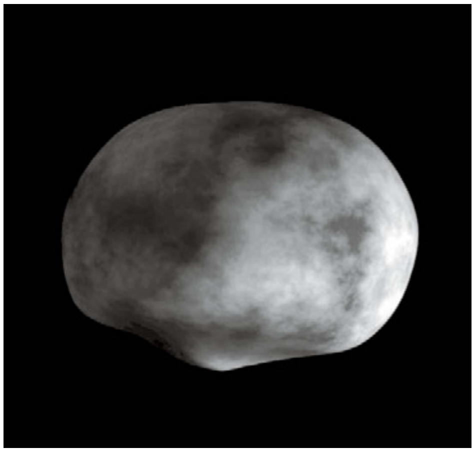

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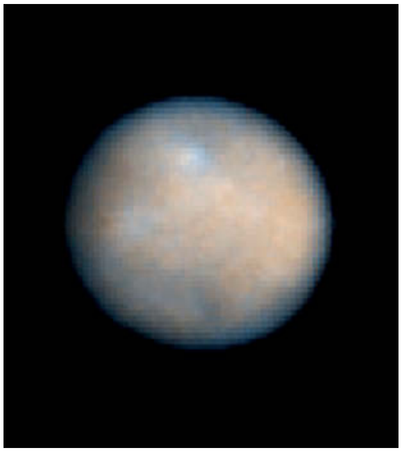

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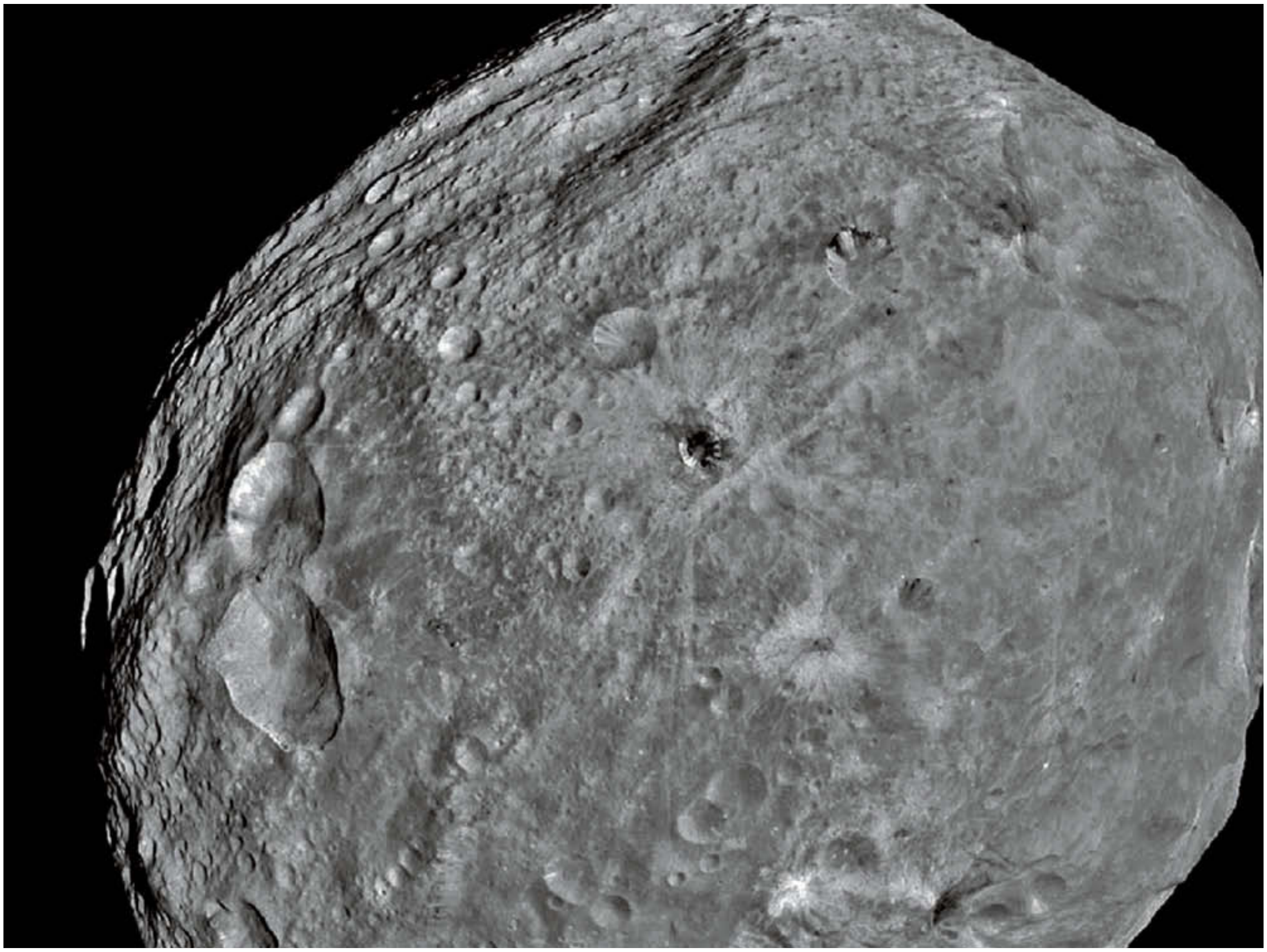
DAWN DESTINATIONS ***Left:*** Prior to Dawn's arrival, the best images of Vesta came from the Hubble Space Telescope. These color-enhanced Hubble images, taken on February 28, 2010, clearly show Vesta's potato-like shape and surface color variations. ***Center:*** Using Hubble data, scientists constructed this 3-dimensional shape model of Vesta, which accurately predicted the south-polar crater and high central peak. ***Right:*** This color-enhanced Hubble image will probably be the best picture we will have of asteroid 1 Ceres until Dawn's arrival in early 2015.



NASA / JPL-CALTECH / UCLA / MPS / DLR / IDA

THE SNOWMAN Mission scientists affectionately named the crater grouping on the left "the Snowman," for obvious reasons. The largest crater is about 65 km across. The two big craters might have been gouged by the impact of a binary asteroid.

Some grooves have huge cliffs that are reminiscent of some of the most dramatic topography on other worlds, such as the ice cliffs of Uranus's moon Miranda or the steep canyon walls of Valles Marineris on Mars. Higher-resolution images will surely reveal even more spectacular landforms.

Scientists are particularly interested in the results from Dawn's spectrometers, which will provide critical details about Vesta's composition and mineralogy. The early views from the camera's color filters confirm previous findings that Vesta is not a uniform chunk of rock (like the much smaller asteroids Eros and Itokawa). But what kinds of minerals lie on the surface, and can they confirm the hypothesis that Vesta has differentiated? Is Vesta's chemistry really like that of the HED meteorites? Will Dawn find any evidence of hydrated minerals or subsurface ice?

The infrared spectrometer's initial data reveal albedo, color, and temperature contrasts, but it will take more time to build a complete picture. Similarly, the gamma-ray and neutron spectrometers will need many months in lower-altitude orbits to collect their specific data sets. Dawn's mission is a marathon, not a sprint, and so we'll all have to be patient as the instruments and team collect their data over the year-long orbital tour. Still, even these early glimpses confirm Chris Russell's observation that Vesta is a "beautiful and exciting small world." ✦

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*S&T contributing editor **Jim Bell** is a professor of astronomy and planetary science at Arizona State University. He was involved in the NEAR-Shoemaker mission to the asteroid 433 Eros, and is the leader of the Mars Exploration Rover Pancam team. He is the recipient of the American Astronomical Society's 2011 Carl Sagan Medal for Excellence in Public Communication in Planetary Science.*

Listen to an AUDIO INTERVIEW

To listen to author Jim Bell discuss the latest findings from Vesta and the Mars rovers, visit SkyandTelescope.com/Vesta.

Sean Walker

Lunt's New 80-mm Hydrogen-alpha Solar Scope

This compact solar scope packs a punch.

S&T: DENNIS DI CICCO

Lunt Solar System's new LS80T Hα dedicated solar telescope features an 80-millimeter f/7 objective and a pressure-tuning etalon. With the exception of a mount, the scope comes standard with everything you need to start observing the Sun in hydrogen-alpha light.

IT'S HARD TO BELIEVE that barely a decade ago, dramatic views of the Sun at the hydrogen-alpha (Hα) wavelength was beyond the reach of most amateur astronomers. Few of us could afford the multi-thousand-dollar cost of the complex Hα filters that revealed stunning activity on the Sun's disk. We might get a look through one at a school or planetarium, but most of us could only dream about personally owning such a setup.

How times have changed! Today, at least four manufacturers specialize in Hα filters and dedicated telescopes that bring dynamic views of the solar chromosphere within reach of the typical amateur. One up-and-coming player in this field is Lunt Solar Systems. The company's principal optical designer is Andrew Lunt, son of the late David Lunt, who readers may recall as the founder of Coronado, a company that revolutionized the solar-astronomy scene by perfecting Hα filters that didn't require complex heaters. Andy continues to build upon his father's legacy with Lunt Solar Systems. For this review we borrowed the LS80T Hα telescope that

Lunt LS80T Hα

U.S. price: $2,999.95 (with B1200 blocking filter, hard case, zoom eyepiece, mounting bar, and solar finder)

Lunt Solar Systems LLC

2520 N. Coyote Dr., #111, Tucson, AZ 85745

luntsolarsystems.com; 520-344-7348

uses the company's new patented pressure-tuned etalon.

The LS80T Hα is sold as a package that includes a foam-lined hard case, a 6-inch Vixen-style mounting bar, a Tele Vue Sol-Searcher solar finder, and a 7.2-to-21.5-mm zoom-eyepiece. New equipment showing up at our *S&T* offices usually attracts a gathering of editors, but a telescope that can be used immediately during the daytime rallies everyone outside. As luck would have it, the sky was clear and we were enjoying fascinating views of a very active Sun within an hour of unpacking the scope.

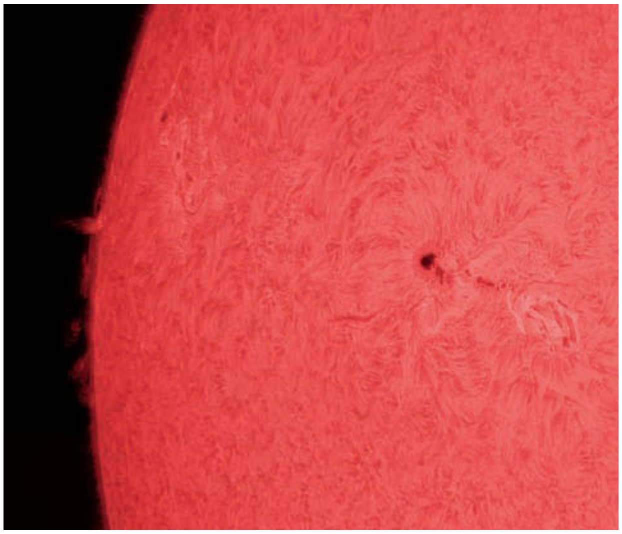
Assembly of the LS80T Hα is straightforward, since you only have to attach the mounting bar and Sol-Searcher. The 6-inch-long Vixen-style dovetail bar includes two ¼-20 threaded holes, which proved particularly helpful on my first day with the telescope. Because the scope's pressure-tuning cylinder extends from the right side of the telescope immediately above the two ¼-20 mounting holes on the tube, I couldn't mount the tube directly to my old Tele Vue Up-Swing mount (the pressure tuner wouldn't fit within the mount's cradle). Adding the dovetail bar to the setup, however, allowed me to offset the pressure tuner outside my mount's cradle, though it put the scope out of balance.

A Tuning Twist

Once outside, I began exploring the nuances of the pressure-tuning device. The manufacturer suggests unscrewing the black cylinder completely to equalize pressure in the system before tuning the scope for the first time. You need to be careful when threading the cylinder back on since it has a four-start thread that can be difficult to engage. You have to push the piston back in while turning the cylinder at the same time to get it back on. I had difficulty doing this at times, especially since I was concerned about cross threading. After using the scope for a few weeks, I found that it was occasionally necessary to equalize the system. For example, taking it to observing locations with elevations that differed by only a few hundred feet usually required equalizing the pressure-tuning system.

Once the system is equalized, to tune the scope I simply kept turning the pressure cylinder until promi-

WHAT WE LIKE:	WHAT WE DON'T LIKE:
Exceptional views of the Sun	Standard Crayford focuser required frequent adjustment
Pressure-tuning system	Pressure tuner difficult to "reset"



S&T: SEAN WALKER

The LS80T Hα's 80-millimeter f/7 objective produces clear, sharp views at high magnifications, allowing you to zoom in on small features such as the thin filaments around sunspots or delicate prominences shown above.

S&T: SEAN WALKER

S&T: DENNIS DI CICCO

***Left*: Though adequate for visual work, the Crayford-style focuser with 10-to-1 speed reduction included with the basic package required occasional adjustment to prevent slipping. *Right*: Equalizing the pressure in the system's etalon is occasionally necessary, requiring you to completely unscrew the pressure cylinder, then thread it back on.**

S&T: SEAN WALKER

Although the scope has two ¼-20 tapped mounting holes on the bottom of the integrated clamshell, users with cradle-style mounts may still need to attach the included dovetail bar to accommodate the pressure-tuning cylinder.

nences started to appear around the solar limb. One word of advice here — the LS80T Hα is a relatively heavy scope for an 80-mm refractor, weighing in at 14 pounds (6.4 kg). Though it can be used on a mid-range photographic tripod, you'll have a much better observing experience if you opt for a heavy-duty tripod or a telescope mount rated for at least this much weight. This is because the tuning system requires you to wrap your entire hand around the pressure cylinder and crank it inward with some force. With a lightweight mount this can lead to very shaky views, which make it difficult to establish the best tuning to see both prominences and details on the solar surface simultaneously. Although my Tele Vue Up-Swing held the scope for quick glances, in general I preferred using the scope on a heavier Vixen Great Polaris DX mount, particularly when I set up the system for imaging.

After everything was together and tuned up, I was able to enjoy the views, and I do mean enjoy! The scope is advertised as having a bandpass of just 0.7 angstrom at the hydrogen-alpha wavelength of 656.28 nanometers, where solar prominences, filaments, active regions, and occasional flares are readily visible. I lucked out during my testing — in late July the Sun displayed a series of large, active sunspots, treating me to some spectacular views, which continued through August.

The basic scope comes with a 2-inch Crayford-style 2-speed focuser with a 10-to-1 reduction ratio, and 1½ inches of travel. While adequate for general use, the focuser often required adjusting the tension to avoid slipping when using the scope on cooler days, and mine had a slightly "scratchy" feeling when racking it back and forth. Lunt offers the scope with an optional Starlight Instruments Feather Touch focuser that, in my opinion, is a worthwhile upgrade, especially for anyone contemplating imaging with heavy cameras.

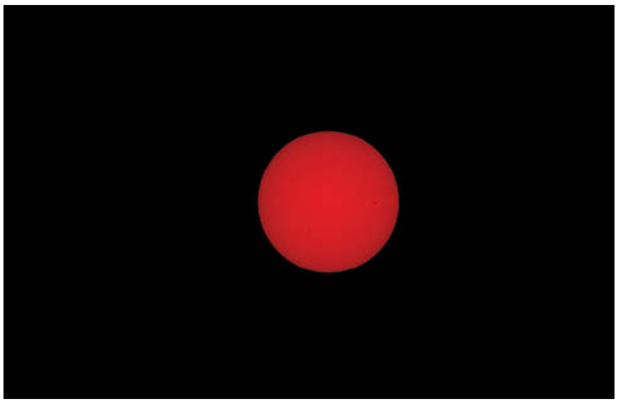
The scope is supplied with its B1200 blocking-filter assembly mounted in a 1¼-inch diagonal permanently attached to a 4-inch-long drawtube used to achieve rough focus. Eyepieces are securely held in the diagonal using a compression ring tightened with two knurled thumbscrews set apart by 90°. Also, the outer edge of the eyepiece holder is threaded to accept T-adapters, so you can attach a DSLR or CCD camera directly to the unit; a very nice touch.

Sweet Spot

All the Hα systems that I've used have a "sweet spot" in the field of view where you see the maximum amount of contrast in detailed solar features. In some scopes the sweet spot appears as a curved region, which sweeps across the field as the filter is tuned. The Lunt scope has a large sweet spot that radiates outward from the center of the field and doesn't appear to move as the filter is tuned. The only thing that makes you aware of the sweet spot is that some solar features became more pronounced when moved to the middle of the field and fade slightly when placed near the edge.

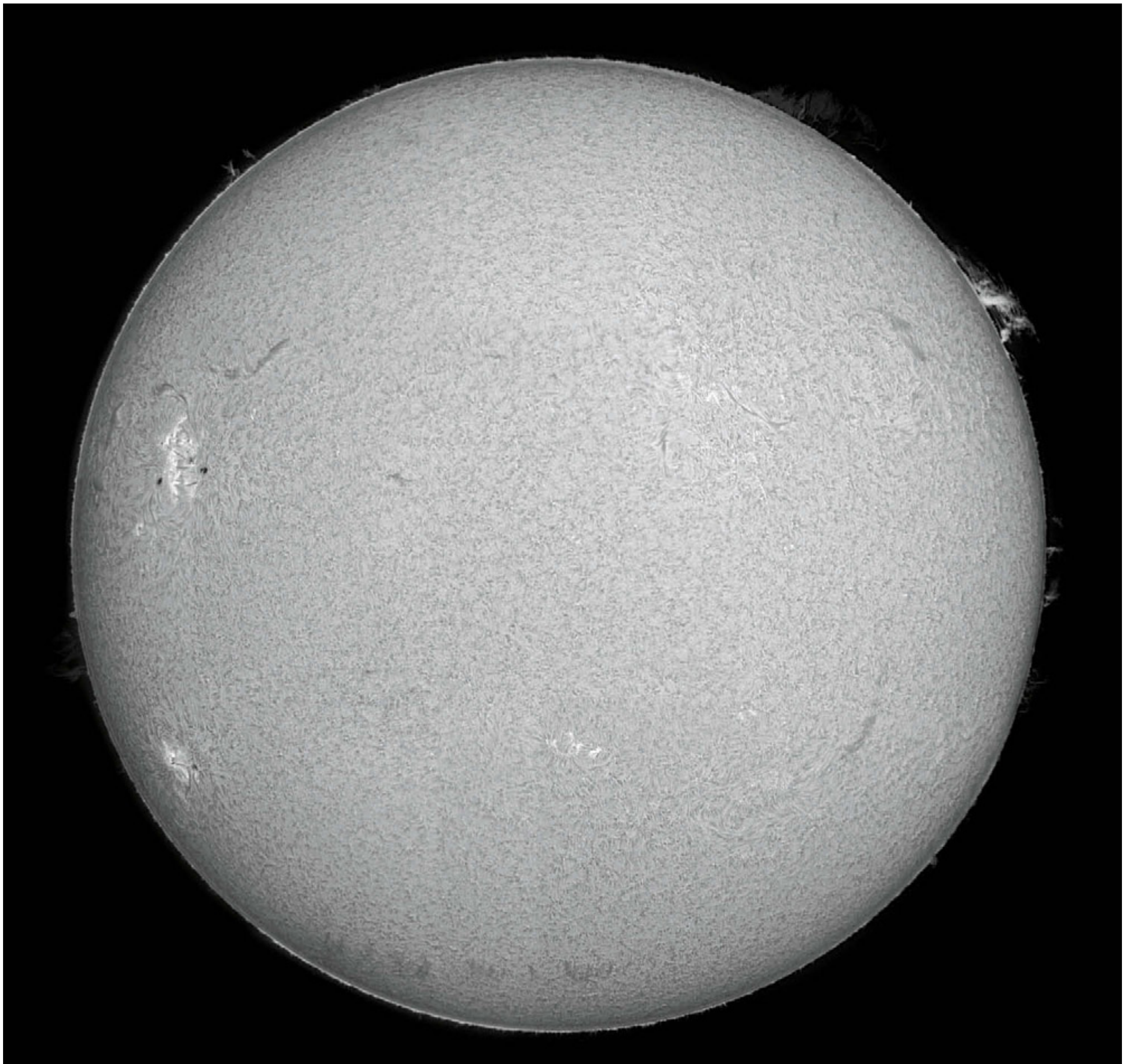
The scope has an extendable dew cap, but I'm not sure why. Usually these are intended for night observing to block the scope's objective from stray light and ward off dew. There certainly aren't any stray-light issues when observing the Sun, and since when is dew a problem during the day? Furthermore, I noticed that when the dew shield was extended its blackened interior would heat up very quickly and produce objectionable air currents that degraded the view. Retracting the dew shield eliminated this problem almost immediately.

The views through the LS80T Hα were stunning, but images taken through the scope were even better. Lunt offers a version of this scope with a larger B1800 blocking filter intended for imaging applications, but I had great success with the basic B1200 filter. As mentioned



S&T: SEAN WALKER

The LS80T Hα includes T-threads on its diagonal to directly attach CCD and DSLR cameras, but the Sun is a paltry 4.9 millimeters across at prime focus seen in this uncropped image made with a Canon Rebel XS DSLR camera.



The LS80T Hα performs exceptionally well photographically when used with webcams and other compact video cameras. The author recorded this mosaic of nine images with an Imaging Source DMK 21AU618 camera and a 2× Barlow.

S&T: SEAN WALKER

earlier, the T-thread on the outer edge of the eyepiece holder allows direct coupling of a DLSR or CCD camera. Although this is handy, the LS80T Hα used at prime focus with a DSLR records the Sun as a very small image only 4.9 millimeters across. The setup really calls for a Barlow lens or other optical amplification.

The basic LS80T Hα is, however, ideal for imaging with the high-speed video cameras popular with today's planetary imagers. I spent many days shooting close-ups of active regions and large prominences with an Imaging Source DMK 21AU618 video camera and a variety of Barlow lenses. With a 2× Barlow, for example, I could create a superbly detailed image of the entire solar disk by overlapping nine frames captured with the camera's small chip.

Overall, I found the Lunt Solar Systems LS80T Hα a joy to use, especially given the fine adjustment that's possible with the scope's pressure-tuning system. Marketed as an intermediate-level instrument, the scope performs like a top-of-the-line system. Andy Lunt is certainly carrying on his father's legacy of technical innovations for solar observers, while making a name for himself in his own right. ✦

Sky & Telescope *imaging editor* ***Sean Walker*** *has been hooked on solar observing for nearly a decade.*

Teaching the Fomalhaut Hour

There's much to learn from this celestial season.

The forest is black in the distance. The landscape is a masterpiece in ultramarine and sable.

As if in contrast, the heavens above blaze with a thousand tints. Incomparable Orion leads the hosts with blue Rigel, ruby Betelgeuse, and bright Bellatrix. His silver belt and sword flash like burnished stellar steel. . . .

How can a person ever forget the scene, the glory of a thousand stars in a thousand hues, the radiant heavens and the peaceful Earth? There is nothing else like it. It may well be beauty in its purest form.

The magnificent Pleiades are celebrated in song and story.

TAD DENTON / ADAM BLOCK / NOAO / AURA / NSF

THE PASSAGE ABOVE is from a journal entry that Walter Scott Houston presented in his January 1991 *Deep-Sky Wonders* column, one of the many hundreds that he wrote for *Sky & Telescope*.

When I read the full passage to a group in public, I often get nods of approval. But then I tell the group something else, and I often get a few gasps: Scotty wrote this when he was 13 years old.

There have been few amateur astronomers or astronomy writers who could compare with Walter Scott Houston. But we should not underestimate what young people can learn —or what the sky can teach them.

Teaching the sky at the Fomalhaut Hour. If you're reading this in November, you'll have to wait until late evening to see Scotty's "incomparable Orion" come up. Our all-sky map shows the view of the sky before Orion rises, a time when the lonely 1st-magnitude star Fomalhaut is at its highest in the south. But there's plenty available at this hour to help teach astronomy — and to teach *with* astronomy.

Astronomy can serve as a conduit to the incredible richness of history, mythology, and literature attached to the stars and constellations. The patterns of the Perseus-Andromeda myth are now well placed in the sky. It's one of the greatest tales ever told. And what could be a more fitting medium than being "written in the stars?"

As for literature, the great 19th-century poet Alfred Lord Tennyson refers to this season's loveliest cluster in his poetic monologue "Locksley Hall:"

Many a night I saw the Pleiads, rising thro' the mellow shade,
Glitter like a swarm of fire-flies tangled in a silver braid . . .

Seeing a great literary simile come to life before their eyes in the form of a beautiful star cluster is surely a spur to young people's interest in both astronomy and literature.

At the Fomalhaut Hour, the Milky Way band and Messier 31 in Andromeda are high and well-placed for an introduction to galaxies. No bright star-birthing nebulae are available for viewing now, but students can be shown the rest of the stellar life cycle, from young open clusters to the planetary nebulae produced by dying stars. The finest double stars (including Albireo in Cygnus and Almach in Andromeda) and variable stars (Algol in Perseus, Mira in Cetus, and Delta Cephei) are all on display. The Great Square of Pegasus, aligned on the 23^h and 0^h lines of right ascension, is a good start for teaching coordinates on the celestial sphere.

A deeper education. Astronomy can also inculcate deeper principles, nurturing valuable habits of mind and heart. Above all else, watching the stars is an education in beauty and an excursion in pure freedom. As Walter Scott Houston said, it may well be beauty in its purest form. ✦

Fred Schaaf welcomes your comments at fschaaf@aol.com.

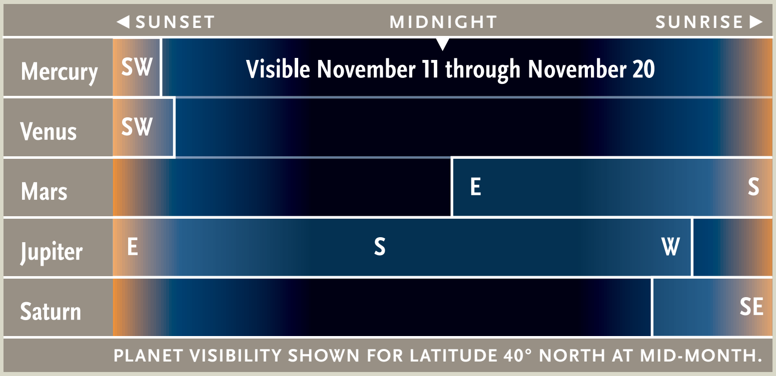
Sky at a Glance

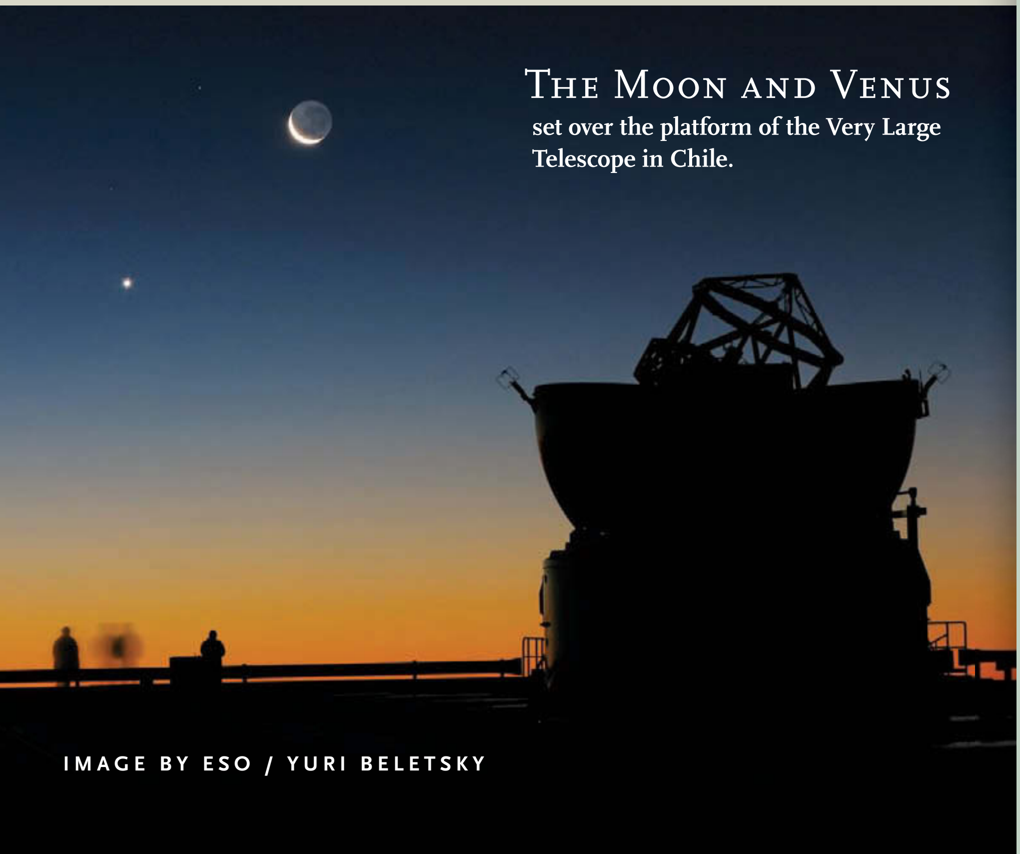
SKY & TELESCOPE

MOON PHASES

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

PLANET VISIBILITY





The Moon and Venus set over the platform of the Very Large Telescope in Chile.

IMAGE BY ESO / YURI BELETSKY

November 2011

Oct. 25 – Nov. 8 PREDAWN: The zodiacal light is visible in the east 80 to 120 minutes before sunrise from dark locations at mid-northern latitudes. Look for a tall, broad, rightward-slanting pyramid of light.

Oct. 28 – Nov. 15 DUSK: Binoculars show Mercury 2° below Venus very low in the southwest a half hour after sunset.

Nov. 2 FIRST-QUARTER MOON (12:38 p.m. EDT).

6 DAYLIGHT-SAVING TIME ENDS at 2 a.m. for most of the U.S. and Canada.

8 EVENING: Asteroid 2005 YU_{55} passes 202,000 miles (325,000 km) from Earth at 6:28 p.m. EST. It's visible across North America in the ensuing hours; see page 53.

9 DUSK: Binoculars show Venus, Mercury, and Antares in a short, nearly straight line very low in the west-southwest a half hour after sunset. Venus, by far the brightest, is at upper right, and Antares, the faintest, is at lower left. Low in the east, Jupiter is about 6° right of the Moon (for North America).

9–12 DAWN: Mars passes 1½° above Regulus these mornings, moving right to left.

10 FULL MOON (3:16 p.m. EST).

DUSK: Last evening's Venus-Mercury-Antares line is more vertical.

11 EVENING: Binoculars show the Pleiades above the bright Moon. The Hyades and Aldebaran are under the Moon.

18 MORNING: The modest Leonid meteor shower peaks in the hours before dawn, but skyglow from the Moon will hide the faintest meteors.

18 LAST-QUARTER MOON (10:09 a.m. EST).

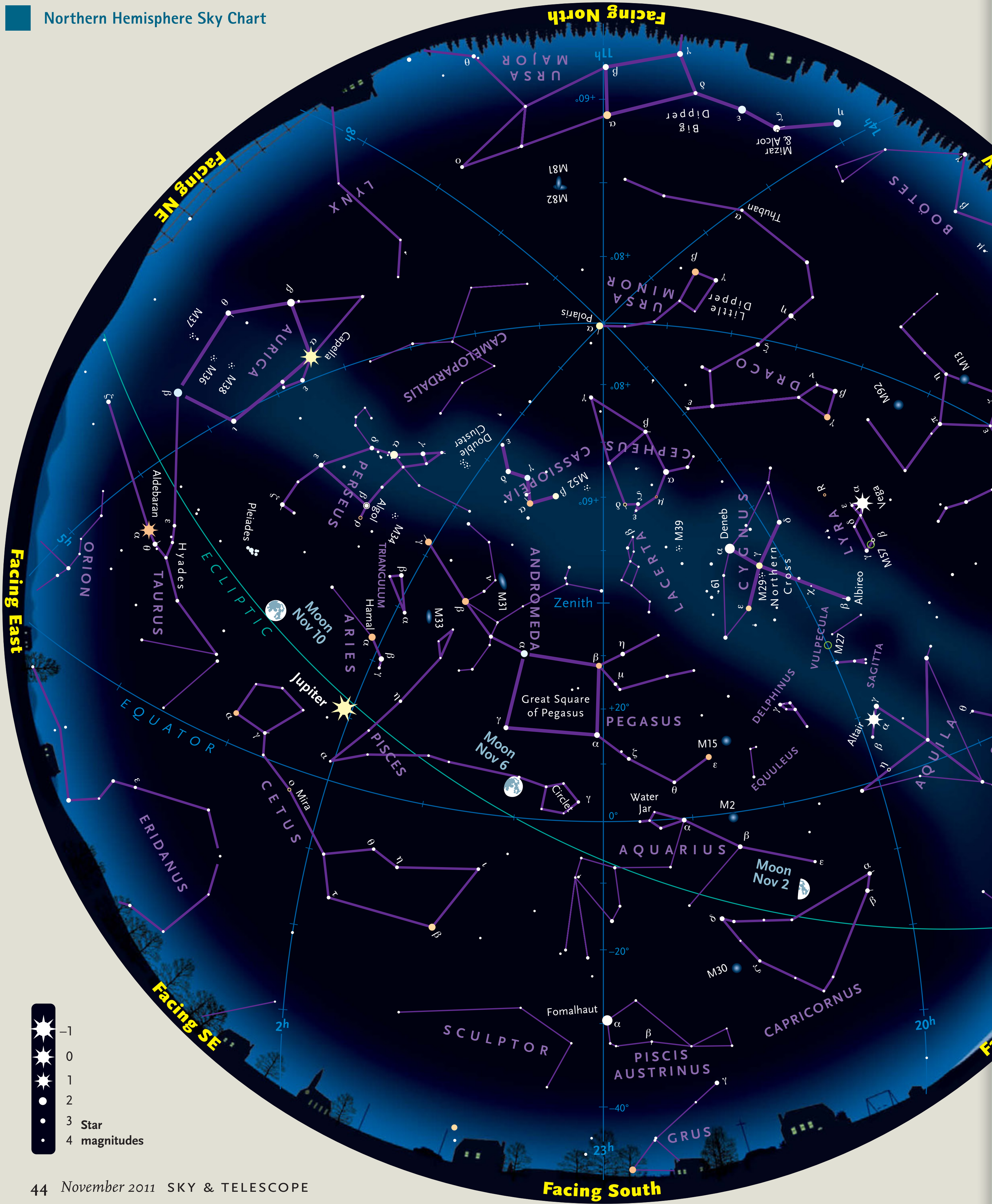
22 Dawn: Saturn, Spica, and the thin waning crescent Moon form a roughly horizontal line in the southeast.

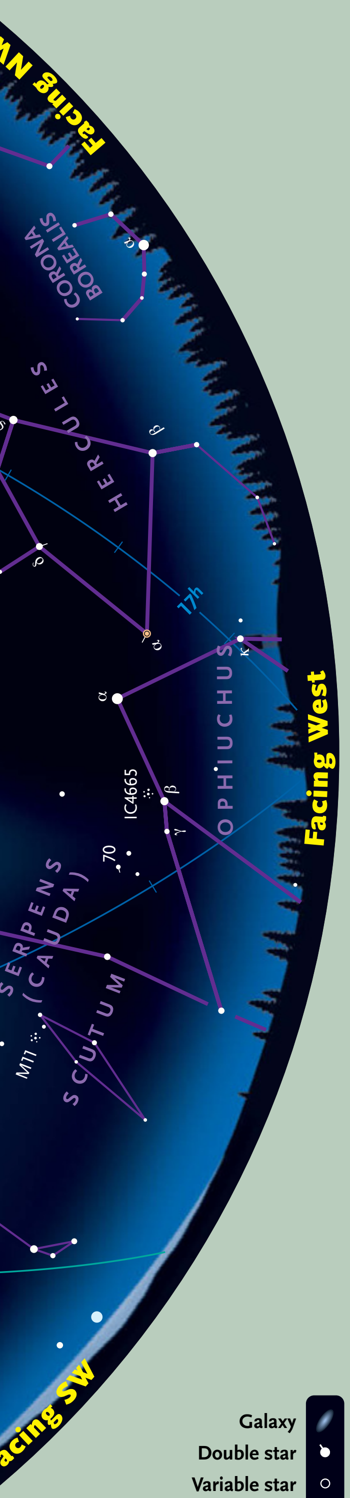
25 NEW MOON (1:10 a.m. EST). A very slight partial solar eclipse is visible in Tasmania, parts of New Zealand, and the southern tip of Africa.

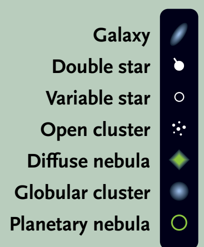
26 DUSK: A very thin crescent Moon is 3° to 5° right of Venus low in the southwest 30 to 60 minutes after sunset (in North America). This is a magnificent sight to the unaided eye and binoculars.

See SkyandTelescope.com/ataglance for details on each week's celestial events.

Northern Hemisphere Sky Chart







Using the Map

WHEN

Late September	Midnight*
Early October	11 p.m. *
Late October	10 p.m.*
Early November	8 p.m.
Late November	7 p.m.

*Daylight-saving time.

HOW

Go outside within an hour or so of a time listed above. Hold the map out in front of you and turn it around so the yellow label for the direction you're facing (such as west or southeast) is at the bottom, right-side up. The curved edge is the horizon, and the stars above it on the map now match the stars in front of you in the sky. The map's center is the zenith, the point overhead. Ignore all parts of the map over horizons you're not facing.

Example: Rotate the map so that "Facing NE" is right-side up. About a third of the way from there to the map's center is the bright yellowish star Capella. Go out, face northeast, and look a third of the way up the sky. There's Capella!

Note: The map is plotted for 40° north (the latitude of Denver, New York, and Madrid). If you're far south of there, stars in the southern part of the sky will be higher and stars in the north lower. Far north of 40° the reverse is true. Jupiter is positioned for mid-November.

You can generate a sky chart that's customized for any location and any time at SkyandTelescope.com/skychart.

Watch a SPECIAL VIDEO

To watch a video tutorial on how to use this sky map, hosted by *S&T* senior editor Alan MacRobert, visit SkyandTelescope.com/maptutorial.

Binocular Highlight: Zenith Cluster M39

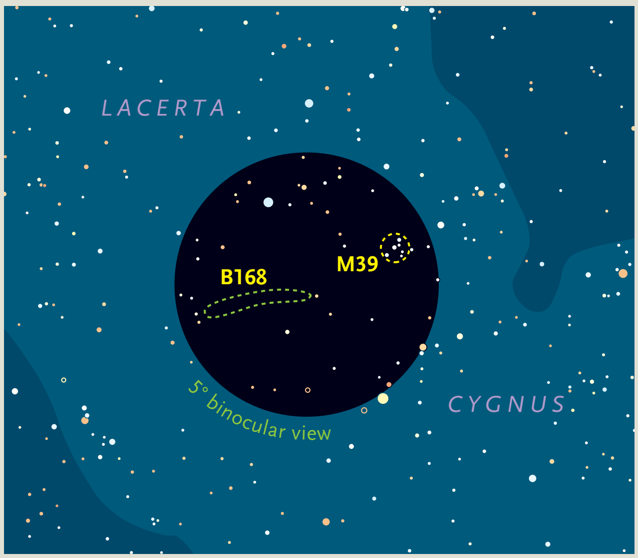
Autumn evenings are bittersweet. The night air no longer seems to hold on to any of the day's warmth, yet the last vestiges of the summer sky continue to pivot overhead. It's a celestial shoulder season — the teeming clusters and nebulae of the Sagittarius Milky Way have slipped into the West, while the brilliant delights of the winter sky have yet to venture into the evening sky. Still, there's much to see with binoculars, including the open cluster **M39**, pivoting near the zenith in Cygnus.

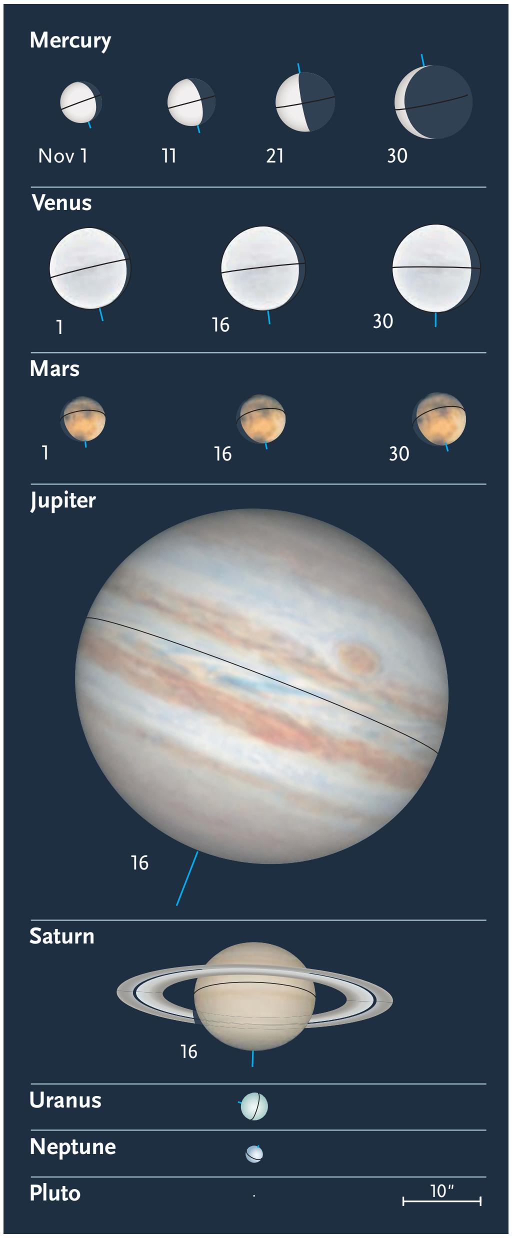
The Swan has only two Messier objects, both open clusters. M29 (described in my November 2010 column) is situated near Gamma (γ) Cygni, and M39 is found along the Milky Way, nearly two binocular fields west-northwest of Deneb, roughly halfway between that star and the dim zigzag of northern Lacerta.

In binoculars M39 is a loose, triangular-shaped grouping delineated by four stars of roughly 7th magnitude. My 10×30 image-stabilized binos draw out a dozen stars in total, while the extra magnification and aperture of my 15×45s brings the count up to two dozen. Nestled against the Milky Way background, it's quite a pretty sight.

If you're observing the cluster under dark skies, you may notice that it lies near a narrow, 3°-long finger of darkness. This is **Barnard 168**, and it seems to point right at M39. Under good (though not pristine) skies, even 10×30s suffice to show the dark nebula quite well. My favorite view of all, however, is through my 10×50s, which combine extra light gathering and magnification with enough field of view to frame the object nicely. At B168's eastern extremity lies the Cocoon Nebula, an object too faint for binocular viewing. ✦

— *Gary Seronik*



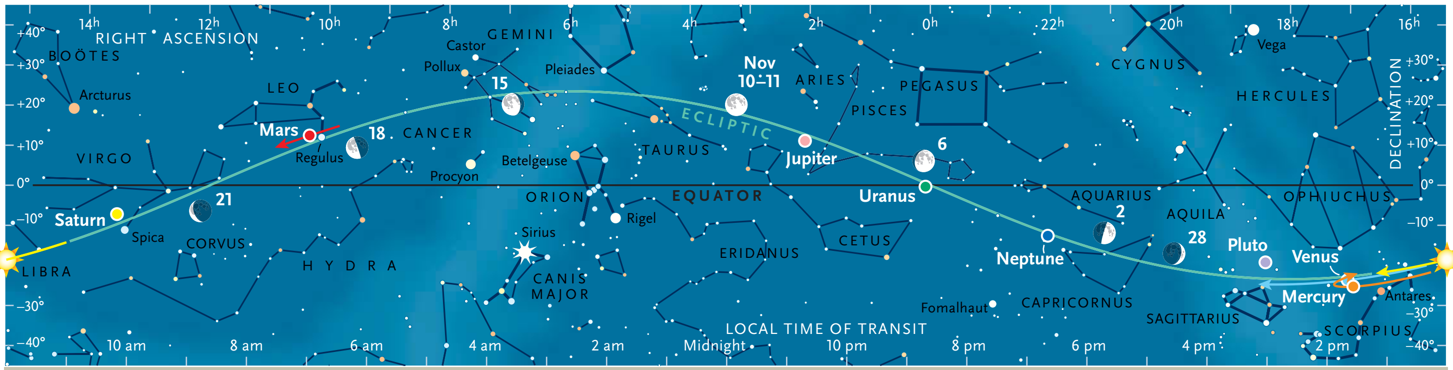


Sun and Planets, November 2011

	November	Right Ascension	Declination	Elongation	Magnitude	Diameter	Illumination	Distance
Sun	1	14^h 22.7^m	–14° 11′	—	–26.8	32′ 13″	—	0.993
	30	16^h 21.8^m	–21° 31′	—	–26.8	32′ 26″	—	0.986
Mercury	1	15^h 38.8^m	–21° 40′	20° Ev	–0.3	5.4″	84%	1.244
	11	16^h 33.4^m	–24° 39′	22° Ev	–0.3	6.2″	70%	1.085
	21	17^h 12.0^m	–25° 14′	21° Ev	–0.1	7.7″	44%	0.876
	30	17^h 04.0^m	–23° 01′	10° Ev	+2.6	9.5″	8%	0.705
Venus	1	15^h 43.3^m	–20° 00′	20° Ev	–3.8	10.6″	94%	1.574
	11	16^h 35.4^m	–22° 43′	23° Ev	–3.8	10.9″	93%	1.536
	21	17^h 29.2^m	–24° 20′	25° Ev	–3.9	11.2″	91%	1.494
	30	18^h 18.3^m	–24° 46′	27° Ev	–3.9	11.5″	89%	1.454
Mars	1	9^h 49.6^m	+14° 51′	73° Mo	+1.1	5.9″	90%	1.583
	16	10^h 19.6^m	+12° 26′	81° Mo	+0.9	6.4″	90%	1.456
	30	10^h 44.7^m	+10° 18′	89° Mo	+0.8	7.0″	90%	1.332
Jupiter	1	2^h 11.8^m	+11° 42′	176° Ev	–2.9	49.6″	100%	3.973
	30	1^h 58.7^m	+10° 38′	144° Ev	–2.8	47.7″	100%	4.135
Saturn	1	13^h 25.6^m	–6° 33′	16° Mo	+0.7	15.6″	100%	10.625
	30	13^h 37.7^m	–7° 41′	42° Mo	+0.8	16.0″	100%	10.395
Uranus	16	0^h 03.8^m	–0° 24′	128° Ev	+5.8	3.6″	100%	19.459
Neptune	16	22^h 01.4^m	–12° 42′	95° Ev	+7.9	2.3″	100%	29.904
Pluto	16	18^h 23.8^m	–19° 18′	43° Ev	+14.1	0.1″	100%	32.849

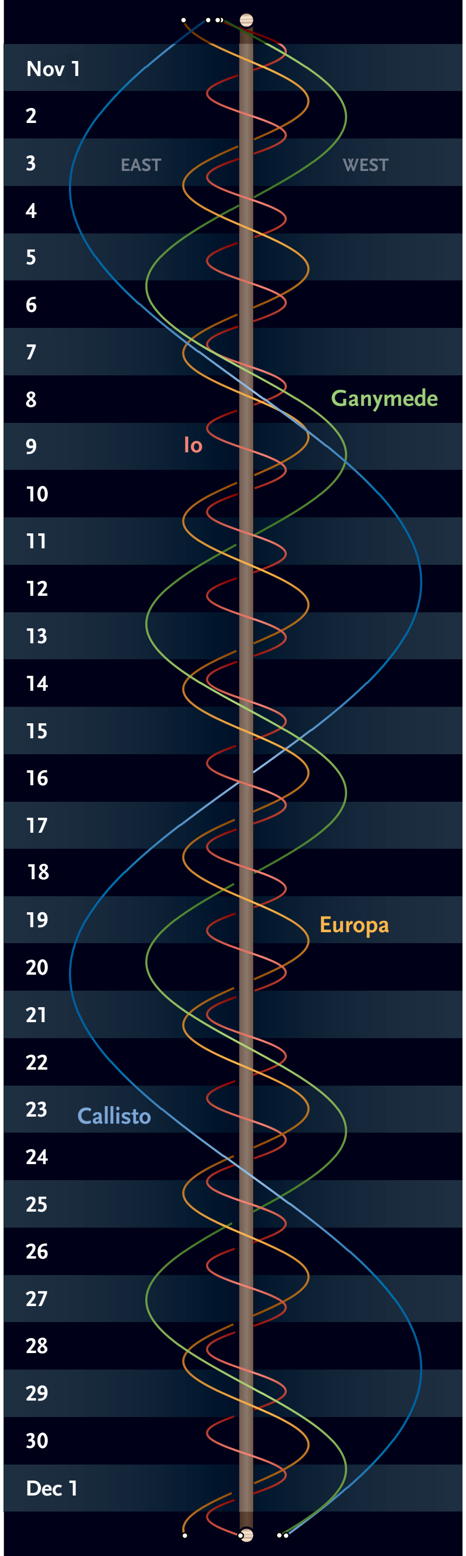
The table above gives each object's right ascension and declination (equinox 2000.0) at 0^h Universal Time on selected dates, and its elongation from the Sun in the morning (Mo) or evening (Ev) sky. Next are the visual magnitude and equatorial diameter. (Saturn's ring extent is 2.27 times its equatorial diameter.) Last are the percentage of a planet's disk illuminated by the Sun and the distance from Earth in astronomical units. (Based on the mean Earth–Sun distance, 1 a.u. is 149,597,871 kilometers, or 92,955,807 international miles.) For other dates, see SkyandTelescope.com/almanac.

Planet disks at left have south up, to match the view in many telescopes. Blue ticks indicate the pole currently tilted toward Earth.



The Sun and planets are positioned for mid-November; the colored arrows show the motion of each during the month. The Moon is plotted for evening dates in the Americas when it's waxing (right side illuminated) or full, and for morning dates when it's waning (left side). All Moon dates are November dates. "Local time of transit" tells when (in Local Mean Time) objects cross the meridian — that is, when they appear due south and at their highest — at mid-month. Transits occur an hour later on the 1st, and an hour earlier at month's end.

Jupiter's Moons



The wavy lines represent Jupiter's four big satellites. The central vertical band is Jupiter itself. Each gray or black horizontal band is one day, from 0^h (upper edge of band) to 24^h UT (GMT). UT dates are at left. Slide a paper's edge down to your date and time, and read across to see the satellites' positions east or west of Jupiter.

Venus Faces Jupiter at Dusk

Venus blazes low in the west as Jupiter ascends in the east.

NOVEMBER NIGHTS this year are rich with planets. Venus starts appearing reasonably high in evening twilight, with Mercury lurking just below it for much of the month. Jupiter is already up in the east at nightfall and is highest in the south before midnight. Mars, passing near Regulus, begins rising around midnight and is highest in the south in morning twilight. And Saturn, near Spica, appears ever higher in the east-southeast at dawn.

DUSK

Venus shines a little higher and stays up a little longer each evening in November, but it's still pretty low in the southwest twilight. If you're near latitude 40° north, Venus's altitude at sunset increases from 9° to 14° during November, and the interval between sunset and Venus-set grows from 1 to 1¾ hours.

Although Venus shines at magnitude –3.8 or –3.9, it's hard to locate until 10 or 15 minutes after sunset. And it might be more like 30 minutes after sundown, even with binoculars, before we first detect a certain fainter point of light below Venus.

Mercury remains almost exactly 2° under Venus for the first half of November, shining at magnitude –0.3, though there's no conjunction in right ascension between the two during this encounter. By the end of this period, Mercury should be high enough a half hour after sunset to view with the unaided eye; before that you'll need binoculars.

After November 15th, Venus pulls away to Mercury's upper left. In the final 10 days of November Mercury drops and fades from magnitude zero to 3 — too faint to see in the bright twilight glow. Venus, meanwhile, continues climbing in what will be a grand, high evening apparition this winter and spring.

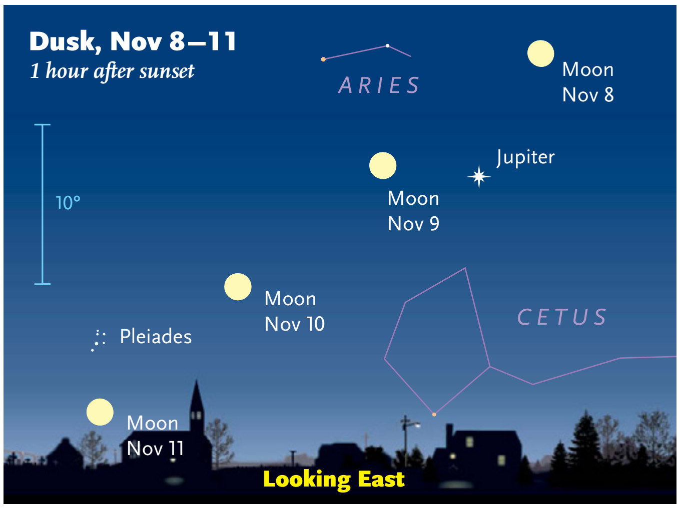
EVENING

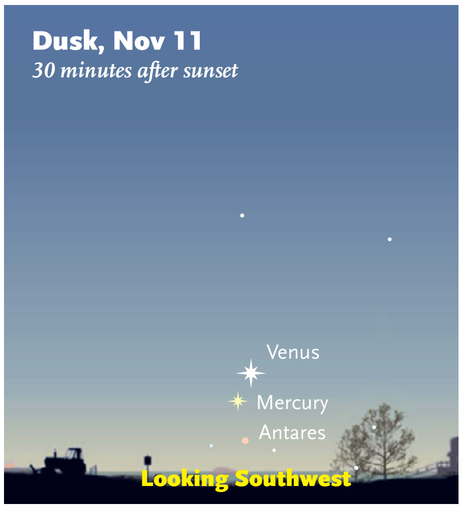
Jupiter was at opposition on October 29th, so in November it's still visible almost all night. For many people, this will be the best month to view Jupiter. It remains near its maximum brilliance (magnitude –2.9 or –2.8), and its disk shrinks barely perceptibly, from 49.6″ to 47.7″ wide. And after opposition is when you can get good telescopic views of a planet high in the sky without staying up late. Jupiter is already halfway up the sky around 10 p.m. daylight-saving time on November 1st, and it's approaching its highest in the south by 8 or 9 p.m. standard time on the 30th.

Where among the constellations does Jupiter shine? In reasonably dark skies you can see the head of Cetus not far to its lower left for most of the evening. But Jupiter is actually in southwestern Aries. It's retrograding (moving west relative to the stars) and almost reaches the border of Pisces by month's end.

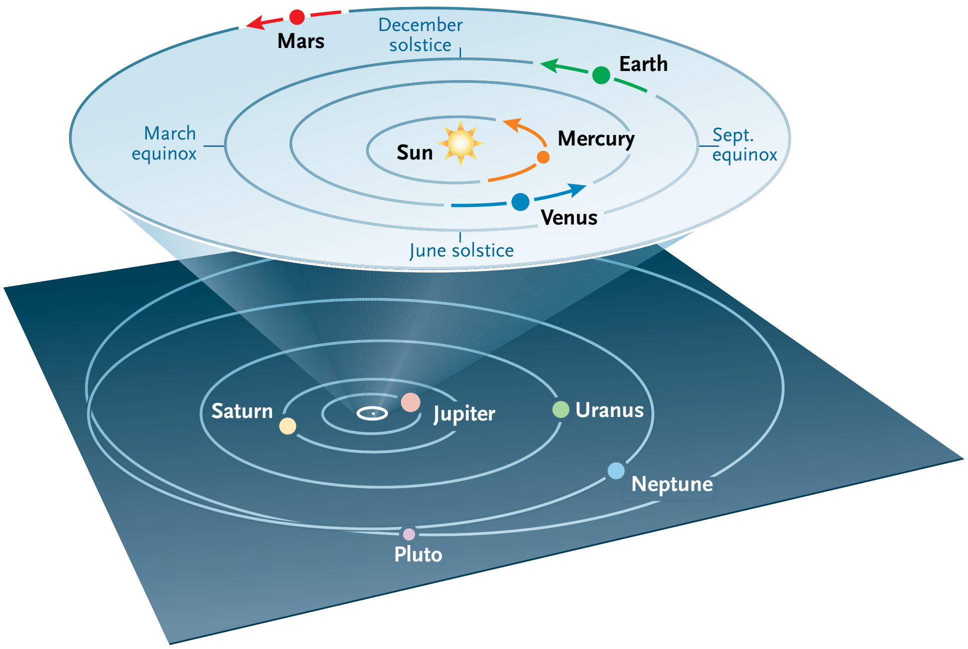
Uranus, in Pisces, and **Neptune**, in Aquarius, are highest in the south during the first few hours after dark. They shine at magnitude 5.8 and 7.9, respectively. You can locate them with the finder charts at **SkyandTelescope.com/uranusneptune** or on page 53 of the September issue.

Pluto, in Sagittarius, is disappearing into the sunset.





These scenes are drawn for near the middle of North America (latitude 40° north, longitude 90° west); European observers should move each Moon symbol a quarter of the way toward the one for the previous date. In the Far East, move the Moon halfway. The blue 10° scale bar is about the width of your fist at arm's length. For clarity, the Moon is shown three times its actual apparent size.



To see what the sky looks like at any given time and date, create your own chart at **SkyandTelescope.com/skychart**.

PREDAWN AND DAWN

Mars rises around 1 a.m. daylight-saving time at the start of November but as early as 11:30 p.m. standard time by the end of the month. It's finally starting to brighten significantly, improving its magnitude from +1.1 to +0.7 during November. Mars glides past 1.4-magnitude Regulus this month, and when they're close together the colors of orange-yellow Mars and blue-white Regulus are enhanced by their contrast. Mars is closest to Regulus (1.2°) on the night of November 10–11. It's within 2° of Regulus for 5 days and within 5° for 19 days.

Mars grows from 5.9″ to 7.1″ wide in November — still small enough that most telescopic observers will struggle to make out many surface features.

Saturn rises about 6 a.m. daylight-saving time on November 1st and around 3:30 a.m. standard time on November 30th. By month's end Saturn is more than 25° high an hour before sunrise. That's still not ideal for telescopic observations, but the reopening of Saturn's rings now is so exciting that many observers will be out looking anyway. During November the ring tilt increases from 12½° to almost 14°, up from its maximum of 10° during Saturn's last apparition.

At magnitude +0.7 or +0.8, Saturn slightly outshines Spica, its continuing companion, which sparkles to its right or lower right at magnitude +1.0. Their separation reaches a minimum of 4.3° on November 14th, and they're still only 4.7° apart at month's end.

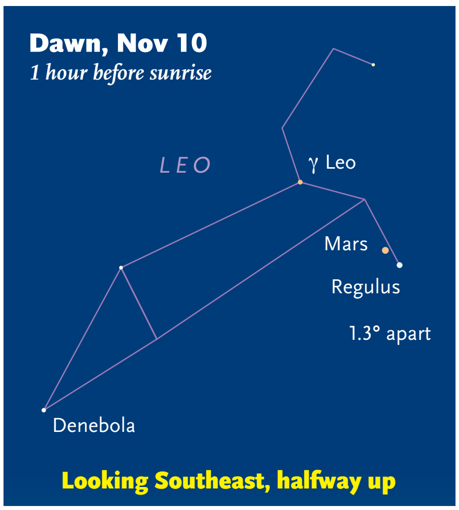
MOON AND SUN

The **Moon** is practically full on November 9th as it glows in the east at dusk with Jupiter to its right. On the morning of November 18th the waning lunar crescent lines up with Regulus and Mars, and on the morning of the 22nd it lines up with Spica and Saturn. At dusk on the 26th, North Americans will see the very slender waxing crescent shining 3° or 4° to the right of Venus.

The **Sun** is partially eclipsed on November 25th for viewers in Antarctica, Tasmania, and small sections of South Africa and New Zealand. ✦

ORBITS OF THE PLANETS

The curved arrows show each planet's motion during November. The outer planets don't change position enough in a month to notice at this scale.



Ruddy Mars Returns

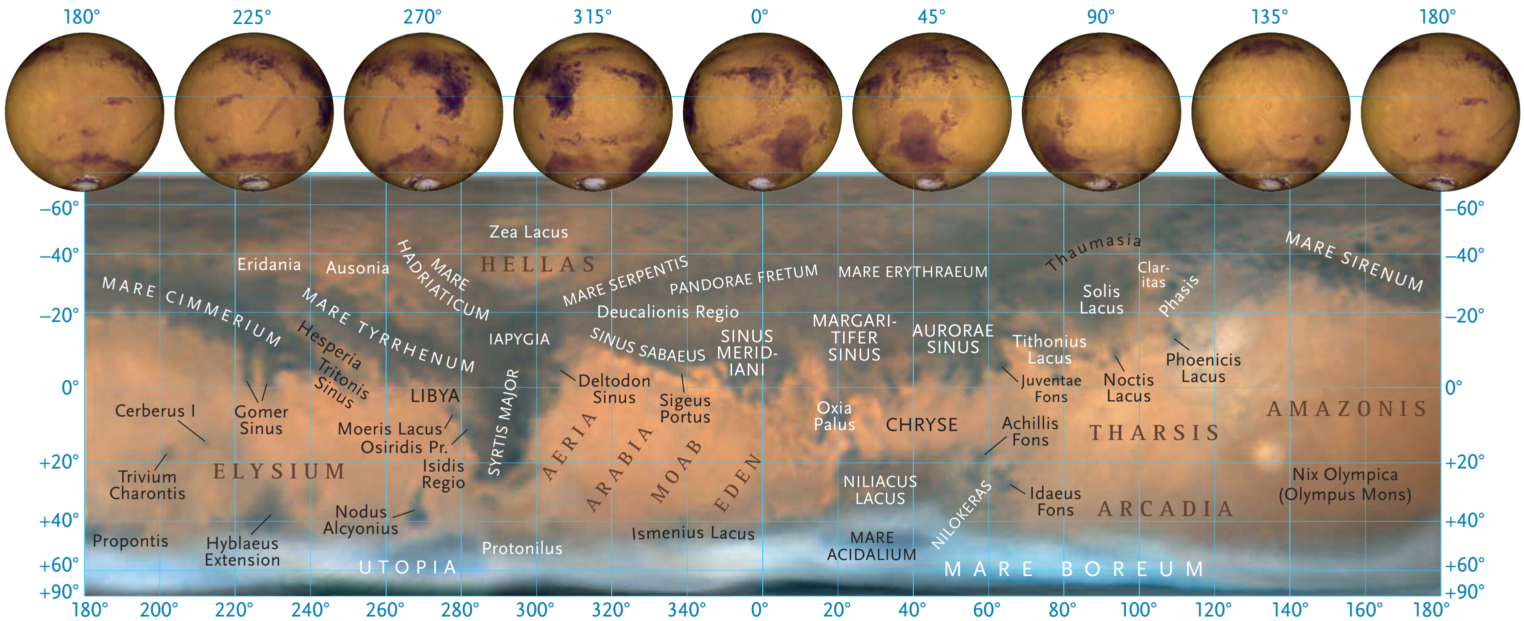
Make the most of the coming apparition.

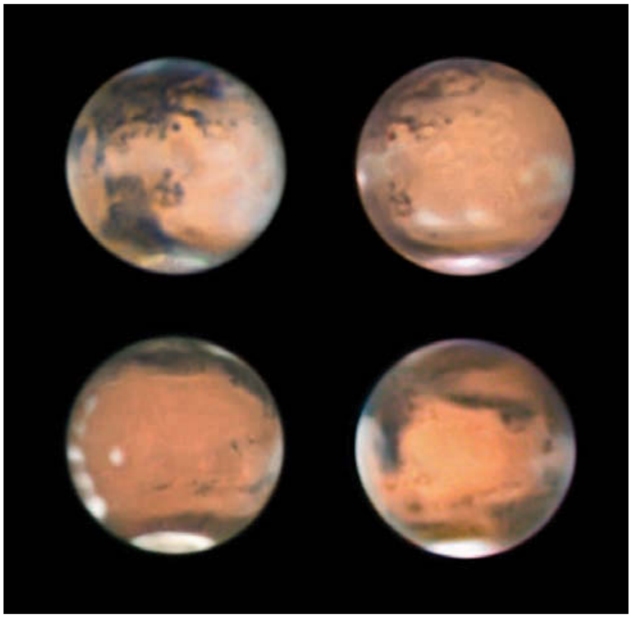
Once again, Mars is beckoning to us from the night sky, using the same magic that enthralled Schiaparelli, Lowell, and Antoniadi. Perhaps it's the Earth-like character of this distant world that captivates us — its clouds and seasons, ever-changing polar caps, or its vast deserts with their unpredictable dust storms. Like far-off places on Earth, it seems to be a place that we could someday visit, like Timbuktu in the hot, shifting Sahara. Is our wonder the result of our having read fictional tales of adventures on the Red Planet? No. Rather, the fictions were inspired by wonder.

The mysteries of the Red Planet that entranced the great observers of old are nearly palpable, enlivened rather than buried by the knowledge we've accumulated since their days. Is there, or has there been, life on Mars? What causes the long-term changes in the shapes of the planet's dark albedo features? Are there complexities of the water and wind cycles of which we have no inkling? While we don't have the answers to these questions yet, we do know these things: Gazing across the void from the humble perspectives of our backyards, we can peer directly upon the surface of Mars. You can imagine that the dark albedo markings are vast continents and islands made of something unknown — not oceans, despite their provocative names, nor vegetation, despite the yearnings of Lowell, but something still unknown.

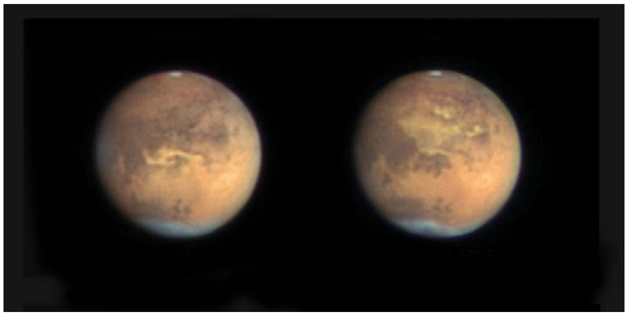
Now in Leo, Mars's ruddy beacon is slightly brighter than any star in the surrounding constellations. You can follow its progress across the sky from month to month in the Planetary Almanac on page 46, or you can use your favorite computer planetarium program to localize it more precisely. Its diameter will subtend more than 6 arcseconds from early November through mid-July 2012, the

With Mars shining high in the east before dawn, it's the perfect time to get an early start observing the coming apparition. The map compiled below by Damian Peach displays the major features visible in modest telescopes. This year, the planet's north pole will be tipped prominently toward us, giving observers a great view as the North Polar Cap slowly recedes as spring progresses in the planet's northern hemisphere.





DON PARKER



Above: **Massive dust storms occasionally erupt during Martian springtime, and they can spread to obscure large areas within days. Alan Friedman captured a light-colored storm in Aurorae Sinus on October 19, 2005 (left), which spread north into Mare Erythraeum by October 21st (right).**

Left: **In addition to prominent albedo markings, Mars displays an ever-changing array of subtle clouds and fogs. Most notable are orographic clouds that form around the prominent volcanoes in the Tharsis region visible in the bottom-left photo.**

minimum necessary to begin to resolve surface features visually. But dedicated planetary observers have already been monitoring it carefully for months.

This will be an *aphelic* apparition of Mars; Mars is on the outer arc of its oval orbit when Earth overtakes it. Thus its apparent size is smaller than it was in recent apparitions. But don't be discouraged by the Red Planet's diminutive disk. Near opposition during a few past aphelic apparitions, I could glimpse the polar caps and a few dark features with a telescope as small as a 60-millimeter refractor. An 8-inch Schmidt-Cassegrain will begin to reveal most of the classical albedo features, but in large amateur instruments, the detail will be mesmerizing. Mars's small apparent size hardly matters for serious planetary imagers these days. Advances in camera sensitivity, combined with increasingly efficient stacking software, have produced more detailed images each apparition since 2003, even as each opposition has been farther than the previous one.

The Red Planet continues to favor Northern Hemisphere observers until it finally slips south of the celestial equator next July. Throughout this period of favorable observing, its North Polar Cap (NPC) will be tilted toward Earth. By odd coincidence, Mars's northern hemisphere is always one season ahead of Earth's Northern Hemisphere at opposition, so this apparition we will witness late spring in the planet's northern regions. Watch clouds dissipate over the NPC during late September through October, and monitor the polar cap's shrinkage as it retreats over the next several months.

Mars will appear largest near March 3, 2012, the day of opposition, with an apparent diameter of 13.9 arcseconds, and it will shine at a modestly bright magnitude –1.2. For visual observers, inexpensive color filters are an important aid to gleaning the most detail. A red filter enhances the contrast of surface features, and any dust storms present will appear bright in red. Surface frosts and fogs are often brightest through a green filter, whereas blue obscures the surface and makes most clouds stand out brightly. Under favorable conditions you can see so much detail in the surface markings that it's more than one can draw!

You can increase your chances of satisfying views this apparition by following a few simple techniques. Set up your scope after dark, and try to limit the buildings and concrete beneath your line of sight. Allow your scope to cool for at least two hours before observing. Collimate your optics on a star near Mars, then slew over to the Red Planet. Observe for long periods; you won't see much for a few minutes until your eyes become accustomed to the planet's subtle contrast.

If you see something unusual, such as a bright dust storm, send your observations to the website of planetary groups such as A.L.P.O., the B.A.A., the I.S.M.O., or the International Mars Watch. While spacecraft continue to monitor the planet's global weather, there's no telling how long these spacecraft will continue to operate. Contributing your images, drawings, and observations to these organizations provides an important service to anyone monitoring changes on the Red Planet in near-real time. Make sure to note the time of your observation as well as a description of your equipment.

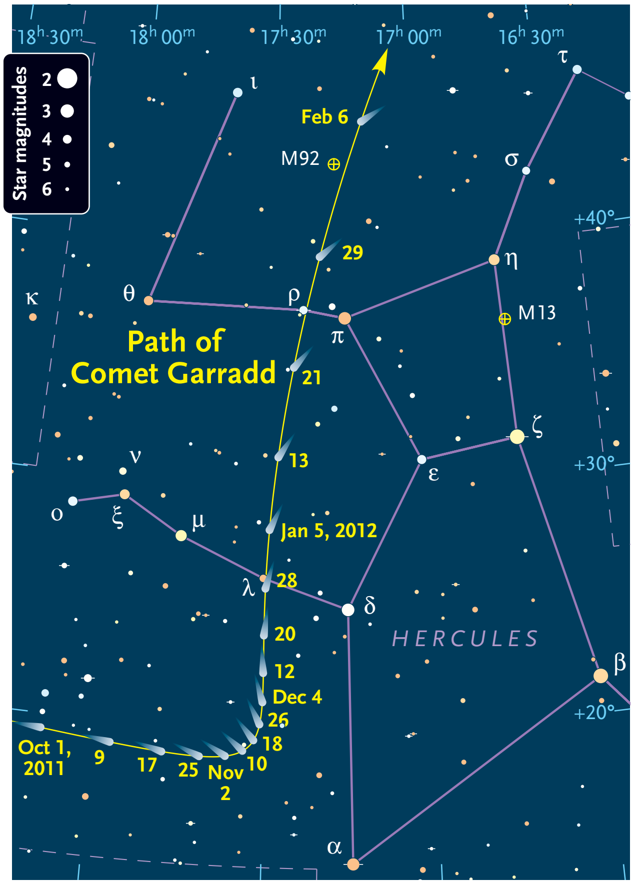
As the only terrestrial planet whose surface we can clearly observe from Earth with seasons that resemble our own, it's no wonder that Mars continues to captivate humanity's imagination. ✦

Roger Venable *is the coordinator of the Mars section of the Association of Lunar and Planetary Observers.*

Comet Garradd After Dark

SOME COMETS COME and go quickly. But Comet C/2009 P1 (Garradd) is something else. It should shine at or near its 6th-magnitude best all through October, November, and December in the evening sky, then all winter in the early hours of the morning.

Nor does Comet Garradd move much this autumn; it spends October, November, and December near the head of Hercules. That means it's high in the west after nightfall in October, lower but still in good view in November, and near the west-northwest horizon at the end of twilight around Christmas. But by then it's already up higher in the east before the first light of dawn; the best viewing tips from evening to morning on December 16th.



Comet Garradd's position is plotted every 8 days at 0:00 Universal Time (which falls on the evening of the previous date in North American time zones). The comet tails point away from the Sun.

Nick Howes in Wiltshire, U.K., caught Comet Garradd passing M71 in Sagitta on the evening of August 26th.

As the comet climbs high in the early-morning sky of January and February, it will pass the Keystone of Hercules, skim ½° by the globular cluster M92 on the morning of February 3rd (mark your calendar), then sail northward past the head of Draco. It should stay bright all the way into spring as it returns to the evening sky.

Why is it changing so slowly? Comet Garradd is unusually large and distant as 6th-magnitude comets go. It never comes closer to the Sun than Mars's average distance; at perihelion on December 23rd it's 1.55 astronomical units from the Sun. Nor does the comet ever come near Earth; it's about 2 a.u. from us all through October and November, and when closest next March 5th it will still be 1.27 a.u. away. Too bad! Garradd might have qualified for "Great Comet" status if had been on a trajectory to pass close to the Sun and if Earth weren't on the wrong side of its orbit at the time.

Astronomer Gordon J. Garradd discovered the comet at 17th magnitude on August 13, 2009, at Australia's Siding Spring Observatory while hunting for, ironically, near-Earth objects.

THE DEMISE OF COMET ELENIN

Observers were expecting another comet, discovered almost a year ago by Russian amateur Leonid Elenin, to become a nice 6th-magnitude target before dawn in October. But in late August Comet Elenin (C/2010 X1) started crumbling away to practically nothing. It wasn't expected to survive its September 10th perihelion.

Mini-Asteroid to Buzz Earth

What's the smallest, closest asteroid you've ever seen with your scope? If you live in North America, mark the evening of Tuesday November 8th to set a new personal record. The little Earth-crossing asteroid 2005 YU_{55} will reach magnitude 11.2 as it races across the sky a little closer than the Moon's distance from Earth.

For the finder chart at bottom, we've selected one prime hour for your asteroid chase. The little object, estimated to be 1,300 feet (400 meters) in diameter, will be so close that your location on Earth significantly affects where you'll see it against the stars (topocentric parallax). So imagine sliding the little upside-down, mirror-image map of the United States across the chart; get out a pencil and ruler and follow the instructions in the caption.

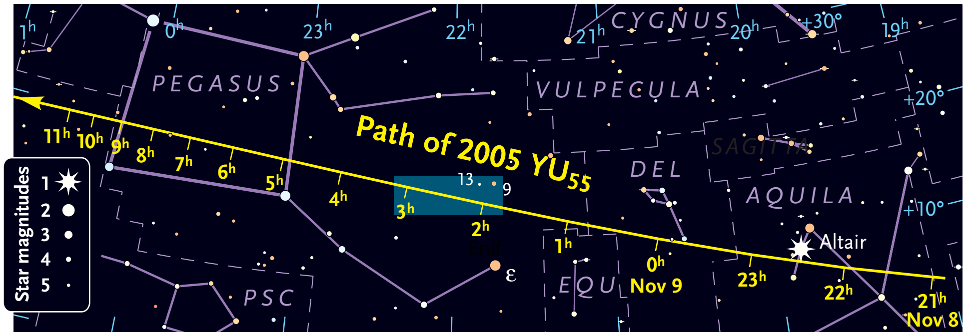
Stars are plotted to magnitude 11.5, just a trace fainter than the asteroid itself. But once you aim at the right place, you shouldn't have much trouble telling which speck it is. It will be creeping right along at 7 arcseconds per second, fast enough to see moving in real time at moderately high magnification.

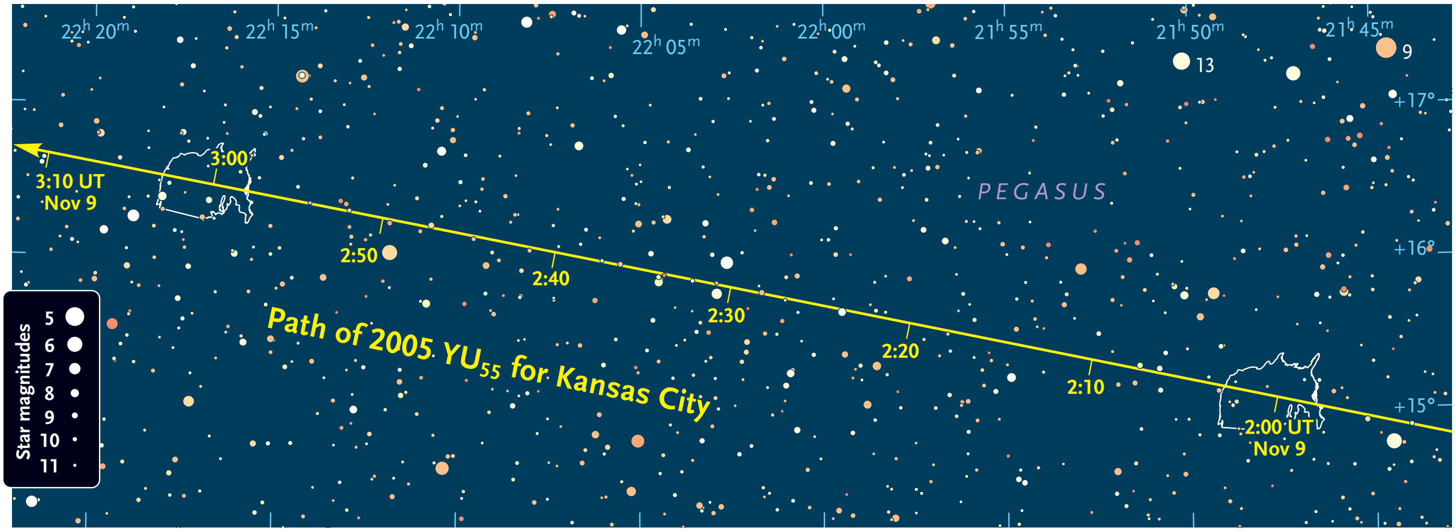
If it looks in your eyepiece like we're dodging a missile in the night, you're right. If 2005 YU_{55} hit Earth the blast would equal several thousand megatons of TNT, compared to 50 megatons for the largest hydrogen bomb ever tested. Fortunately, radar ranging has refined the asteroid's orbit precisely enough to show that there's no chance of it hitting Earth in the next 100 years.

The asteroid is surprisingly round and has a dark, carbonaceous surface. High-resolution radar imagery is planned for the day of closest approach. Because the object went undiscovered during a closer pass in 1976, this flyby will be the closest ever observed of something this large.

Photometry Needed!

To complement the radar observations planned for 2005 YU_{55} during its flyby, astronomers are seeking precise measurements of its changing brightness as it tumbles. A problem is that the asteroid will be moving across the sky so fast that no one station can record a full rotation. Many observers are needed. Amateurs who are set up to do accurate photometry are urged to join this effort; see SkyandTelescope.com/2005yu55. And start planning early.





Best seen from North America, the little asteroid 2005 YU_{55} will race far across the constellations in just 11 hours. On the top chart, the dark blue rectangle shows the area of the close-up below it. There, the asteroid is plotted for just over an hour on the evening of November 8th for North America (from 1:51 to 3:11 November 9th Universal Time). North is up, east is left. On each of the little upside-down, mirror-image maps of the U.S., put a pencil dot on your location. These are the asteroid's apparent positions at 2:00 and 3:00 UT for your site. Connect your dots with a straight line paralleling the line plotted, which is for Kansas City. Then copy the 10-minute tick marks, noting your offset from Kansas City on the U.S. map.

The Jupiter Watch

November is Jupiter's best month this year. The planet is just past its October 28th opposition, still big (49 arcseconds wide for most of the month), and shining higher earlier in the evening each week.

Even the smallest scope shows Jupiter's four big Galilean moons; binoculars usually show at least two or three. Identify them with the diagram on page 47. Listed below are all their interactions with Jupiter's disk and shadow during November, fascinating to watch with a small scope.

On Jupiter itself, the North Equatorial Belt was still dark red-brown as of August. The South Equatorial Belt (SEB) was broader but paler, and the Great Red Spot, sitting in the south edge of the SEB, was still surrounded by an unusually dark rim.

Here are the times, in Universal Time, when the Great Red Spot should cross Jupiter's central meridian. The dates (also in UT) are in bold. Eastern Daylight Time is UT minus 4 hours; Eastern Standard Time is UT minus 5 hours. The Red Spot appears closer to the planet's central meridian than to the limb (edge) for 50 minutes before and after these times:

November 1: 1:29, 11:24, 21:20; **2:** 7:16, 17:11; **3:** 3:07, 13:02, 22:58; **4:** 8:54, 18:49; **5:** 4:45, 14:40; **6:** 0:36, 10:32, 20:27; **7:** 6:23, 16:18; **8:** 2:14, 12:10, 22:05; **9:** 8:01, 17:56; **10:** 3:52, 13:48, 23:43; **11:** 9:39, 19:34; **12:** 5:30, 15:26; **13:** 1:21, 11:17, 21:12; **14:** 7:08, 17:04; **15:** 2:59, 12:55, 22:51; **16:** 8:46, 18:42; **17:** 4:37, 14:33; **18:** 0:29, 10:24, 20:20; **19:** 6:15, 16:11; **20:** 2:07, 12:02, 21:58; **21:** 7:54, 17:49; **22:** 3:45, 13:41, 23:36; **23:** 9:32, 19:27; **24:** 5:23, 15:19; **25:** 1:14, 11:10, 21:06; **26:** 7:01, 16:57; **27:** 2:53, 12:48, 22:44; **28:** 8:39, 18:35; **29:** 4:31, 14:26; **30:** 0:22, 10:18, 20:13.

These times assume that the spot is centered at System II longitude 173°. If it's elsewhere, it will transit 12/3 minutes late for every 1° of longitude greater than 173°, or 12/3 minutes early for every 1° less than 173°. Markings on Jupiter appear a little more contrasty through a blue or green eyepiece filter. ✦

Minima of Algol

Oct.	UT	Oct.	UT	Nov.	UT
3	6:11	26	4:42	15	6:24
6	3:00	29	1:30	18	3:13
8	23:49	31	22:19	21	0:02
11	20:38	**Nov.**	**UT**	23	20:51
14	17:26	3	19:08	26	17:40
17	14:15	6	15:57	29	14:29
20	11:04	9	12:46		
23	7:53	12	9:35		

Predictions courtesy Gerry Samolyk, AAVSO.

Phenomena of Jupiter's Moons, November 2011

Nov. 1	6:54	II.Tr.I
	7:02	II.Sh.I
	9:16	II.Tr.E
	9:30	II.Sh.E
	13:32	I.Oc.D
	15:47	I.Ec.R
Nov. 2	10:39	I.Tr.I
	10:46	I.Sh.I
	12:48	I.Tr.E
	12:56	I.Sh.E
Nov. 3	1:01	II.Oc.D
	3:43	II.Ec.R
	7:58	I.Oc.D
	10:15	I.Ec.R
Nov. 4	5:05	I.Tr.I
	5:15	I.Sh.I
	7:13	III.Oc.D
	7:14	I.Tr.E
	7:25	I.Sh.E
	9:36	III.Ec.R
	20:01	II.Tr.I
	20:20	II.Sh.I
	22:23	II.Tr.E
	22:48	II.Sh.E
Nov. 5	2:24	I.Oc.D
	4:44	I.Ec.R
	23:31	I.Tr.I
	23:43	I.Sh.I
Nov. 6	1:40	I.Tr.E
	1:54	I.Sh.E
	14:08	II.Oc.D
	17:02	II.Ec.R
	20:50	I.Oc.D
	23:13	I.Ec.R
Nov. 7	17:57	I.Tr.I
	18:12	I.Sh.I
	20:06	I.Tr.E
	20:22	I.Sh.E
	20:59	III.Tr.I
	21:49	III.Sh.I
	22:27	III.Tr.E
	23:45	III.Sh.E
Nov. 8	9:08	II.Tr.I
	9:38	II.Sh.I
	11:30	II.Tr.E
	12:05	II.Sh.E
	15:16	I.Oc.D
	17:42	I.Ec.R
Nov. 9	12:23	I.Tr.I
	12:41	I.Sh.I
	14:32	I.Tr.E
	14:51	I.Sh.E
Nov. 10	3:16	II.Oc.D
	6:21	II.Ec.R
	9:42	I.Oc.D
	12:10	I.Ec.R
Nov. 11	6:49	I.Tr.I
	7:10	I.Sh.I
	8:58	I.Tr.E
	9:20	I.Sh.E
	10:27	III.Oc.D
	13:38	III.Ec.R
	22:15	II.Tr.I
	22:56	II.Sh.I
Nov. 12	0:37	II.Tr.E
	1:23	II.Sh.E
	4:07	I.Oc.D
	6:39	I.Ec.R
Nov. 13	1:15	I.Tr.I
	1:39	I.Sh.I
	3:24	I.Tr.E
	3:49	I.Sh.E
	16:23	II.Oc.D
	19:40	II.Ec.R
	22:33	I.Oc.D
Nov. 14	1:08	I.Ec.R
	19:42	I.Tr.I
	20:07	I.Sh.I
	21:50	I.Tr.E
	22:18	I.Sh.E
Nov. 15	0:13	III.Tr.I
	1:46	III.Tr.E
	1:50	III.Sh.I
	3:45	III.Sh.E
	11:22	II.Tr.I
	12:14	II.Sh.I
	13:45	II.Tr.E
	14:41	II.Sh.E
	17:00	I.Oc.D
	19:36	I.Ec.R
Nov. 16	14:08	I.Tr.I
	14:36	I.Sh.I
	16:17	I.Tr.E
	16:46	I.Sh.E
Nov. 17	5:31	II.Oc.D
	8:59	II.Ec.R
	11:26	I.Oc.D
	14:05	I.Ec.R
Nov. 18	8:34	I.Tr.I
	9:05	I.Sh.I
	10:43	I.Tr.E
	11:15	I.Sh.E
	13:42	III.Oc.D
	15:21	III.Oc.R
	15:43	III.Ec.D
	17:39	III.Ec.R
Nov. 19	0:29	II.Tr.I
	1:32	II.Sh.I
	2:53	II.Tr.E
	3:59	II.Sh.E
	5:52	I.Oc.D
	8:34	I.Ec.R
Nov. 20	3:00	I.Tr.I
	3:34	I.Sh.I
	5:09	I.Tr.E
	5:44	I.Sh.E
	18:39	II.Oc.D
	22:18	II.Ec.R
Nov. 21	0:18	I.Oc.D
	3:02	I.Ec.R
	21:27	I.Tr.I
	22:03	I.Sh.I
	23:36	I.Tr.E
Nov. 22	0:13	I.Sh.E
	3:30	III.Tr.I
	5:09	III.Tr.E
	5:53	III.Sh.I
	7:47	III.Sh.E
	13:37	II.Tr.I
	14:50	II.Sh.I
	16:01	II.Tr.E
	17:17	II.Sh.E
	18:44	I.Oc.D
	21:31	I.Ec.R
Nov. 23	15:53	I.Tr.I
	16:32	I.Sh.I
	18:02	I.Tr.E
	18:42	I.Sh.E
Nov. 24	7:49	II.Oc.D
	11:37	II.Ec.R
	13:11	I.Oc.D
	16:00	I.Ec.R
Nov. 25	10:19	I.Tr.I
	11:01	I.Sh.I
	12:29	I.Tr.E
	13:11	I.Sh.E
	17:01	III.Oc.D
	18:44	III.Oc.R
	19:44	III.Ec.D
	21:40	III.Ec.R
Nov. 26	2:45	II.Tr.I
	4:08	II.Sh.I
	5:10	II.Tr.E
	6:34	II.Sh.E
	7:37	I.Oc.D
	10:29	I.Ec.R
Nov. 27	4:46	I.Tr.I
	5:30	I.Sh.I
	6:55	I.Tr.E
	7:39	I.Sh.E
	20:58	II.Oc.D
Nov. 28	0:56	II.Ec.R
	2:03	I.Oc.D
	4:57	I.Ec.R
	23:13	I.Tr.I
	23:58	I.Sh.I
Nov. 29	1:22	I.Tr.E
	2:08	I.Sh.E
	6:51	III.Tr.I
	8:35	III.Tr.E
	9:55	III.Sh.I
	11:48	III.Sh.E
	15:54	II.Tr.I
	17:26	II.Sh.I
	18:19	II.Tr.E
	19:52	II.Sh.E
	20:30	I.Oc.D
	23:26	I.Ec.R
Nov. 30	17:39	I.Tr.I
	18:27	I.Sh.I
	19:48	I.Tr.E
	20:37	I.Sh.E

Every day, interesting events happen between Jupiter's satellites and the planet's disk or shadow. The first columns give the date and mid-time of the event, in Universal Time (which is 4 hours ahead of Eastern Daylight Time; 5 hours ahead of Eastern Standard Time). Next is the satellite involved: **I** for Io, **II** Europa, **III** Ganymede, or **IV** Callisto. Next is the type of event: **Oc** for an occultation of the satellite behind Jupiter's limb, **Ec** for an eclipse by Jupiter's shadow, **Tr** for a transit across the planet's face, or **Sh** for the satellite casting its own shadow onto Jupiter. An occultation or eclipse begins when the satellite disappears **(D)** and ends when it reappears **(R)**. A transit or shadow passage begins at ingress **(I)** and ends at egress **(E)**. Each event is gradual, taking up to several minutes. Courtesy IMCCE.

Come Night

Explore the sky northeast of the Veil Nebula.

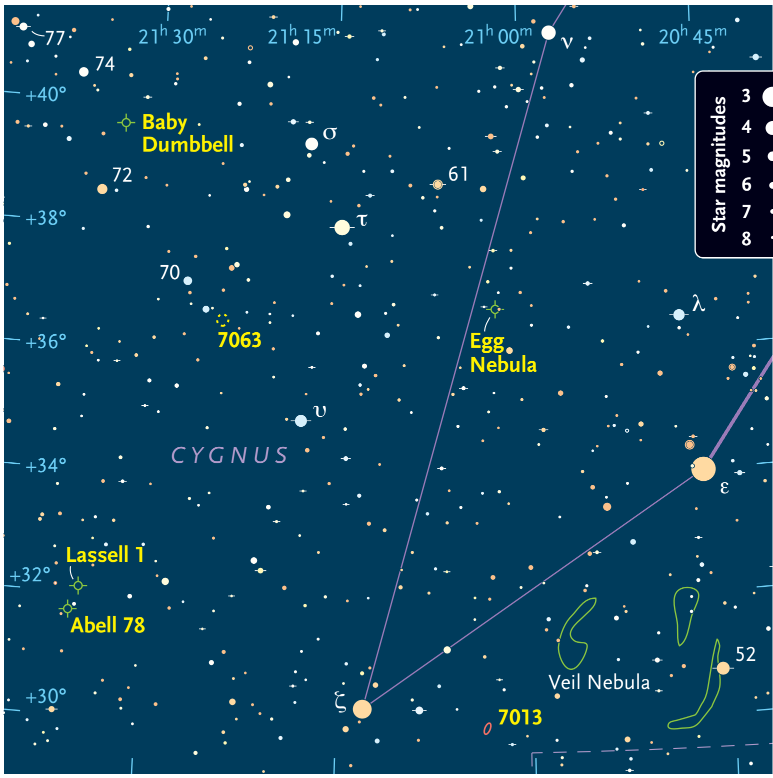
Come, gentle Sister of the starry eyes,
With sable fingers open to our sight
Those fields of unimaginable skies —
Your vast demesne — Come, gentle Sister, Night.
— Albert Durrant Watson, *Night, 1924*

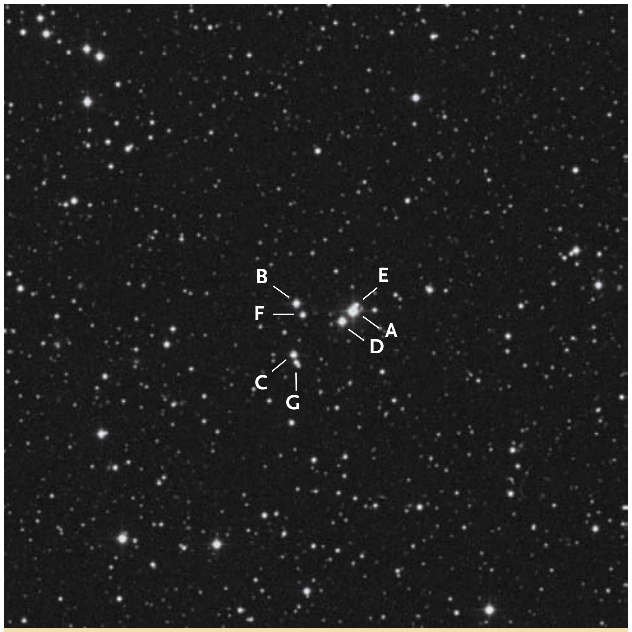
WHEN NIGHT SWEEPS her velvet robes across the sky and casts her glittering gaze our way, she offers us an unending vista of deep-sky wonders to enjoy. Sights new to my eye patiently await discovery in every realm of the heavens. Thanks to a much-appreciated note from accomplished observer and author Steve Gottlieb, I have a novel addition to my roll of favorites: Lassell 1.

The constellation Lyra is famed for the Double-Double (Epsilon Lyrae), two widely separated stars that are each close pairs. But Cygnus has a Triple-Double! It was discovered in 1856 by the British astronomer William Lassell and reported in the *Monthly Notices of the Royal Astronomical Society* the following year. Lassell called it "a singular group of three stars, each attended by a small companion." The pairs mark the corners of a northeast-pointing isosceles triangle with a 1.6′ base and 1.2′ sides.

To locate **Lassell 1**, hop 2.1° east from Zeta (ζ) Cygni to a golden 6th-magnitude star, the brightest in the area. Through a finder, this star marks the shared point of two diverging 3-star arcs sweeping northeast for 2.3°, each component shining at magnitude 6 or 7. The stars at the arcs' ends make a shallow curve with a somewhat fainter 7th-magnitude star to their east. Lassell 1 is 18′ north of that star and looks like a hazy star clump at low power. Don't be fooled by a similar clump 8½′ northeast.

The members of this unique stellar arrangement are listed as having magnitudes from 10.6 to 13.5, so I was pleasantly surprised to spot them all at 117× in my 130-mm (5.1-inch) scope. When showing off Lassell 1 at the Peach





POSS-II / CALTECH / PALOMAR OBSERVATORY

The components of Lassell 1 are labeled here by their *Washington Double Star Catalog* designations. The field is 15′ wide, and the "false double" described by the author is in the upper-left corner.

State Star Gaze in Georgia, I boosted the magnification to 164× to evict a distractingly bright star from the field of view. Clockwise starting with the northeastern pair, the component separations are 19″, 22″, and 12″.

The online *Washington Double Star Catalog* lists a 7th star in the system. Faint and rather close to Lassell 1's brightest component, this star wasn't visible through the 130-mm scope. It did make an appearance with my 10-inch reflector at 299×, and it showed better at 374× even though atmospheric turbulence made the stars look furry at that power.

Let's return to the star 18′ south of Lassell 1 and look for a slightly dimmer, orange star 16′ to its southeast. The planetary nebula **Abell 78** sits midway between these stars. While I was star-hopping my way to Abell 78 with my 130-mm scope at 102×, it conveniently popped into view by a fortunate chance of averted vision. Only the central star was evident when looking straight at the nebula. With a slightly higher magnification, I detected a fairly large but vague presence, like a fleeting memory of moonlight. This fragile apparition is attended by a faint star off its east-northeastern edge and a little bunch of stars near its northwestern edge. A narrowband nebula filter makes the planetary a bit clearer, but an O III filter gives a displeasingly dim view in a scope this small. The 10-inch scope at 166× reveals a slightly darker area around the central star.

Images of Abell 78 show a knotty, east-west ring approximately 1.5′ × 0.9′ within a 2′ faint and slightly oval glow tilted northwest. The planetary's outer shell is composed mostly of hydrogen that once made up the outer layers of its progenitor star. The knotty ring is hydrogen-deficient and shines largely by the light of doubly ionized oxygen (O III). It contains large amounts of helium forged in the fires of its parent star and dredged up to the surface along with heavier elements by a late flash of energy from fusion in the star's helium shell. The star, formerly on its way to white dwarfhood, was temporarily reborn as a red giant that entered a second planetary-nebula phase and ejected its hydrogen-depleted envelope into the previous nebular shroud.

Cygnus seldom comes to mind when we think of galaxies, but let's take a peek at **NGC 7013**, located 2.1° west of Zeta Cygni. It's the second-brightest galaxy in Cygnus, topped only by NGC 6946, which straddles the Cygnus-Cepheus border far to the north.

NGC 7013 is merely a faint, elongated glow through my 105-mm refractor at 47×, but the view is much nicer at 87×. The galaxy appears about 2½′ long, tipped north-northwest, and grows considerably brighter toward the center. A 10th-magnitude star dances on its northern tip, while a faint star guards its western flank.

Through my 10-inch reflector at 213×, NGC 7013 covers 3¾′ × 1¼′ with a 1½′-long core and a bright nucleus. The

JIM SHUDER

KENT BIGGS

Top: **Most of the light in Abell 78's outer shell comes from red hydrogen-alpha emissions, while the inner ring puts out mostly blue-green light from oxygen III. *Above:* NGC 7013 is classified as type SA0/a(r), a ringed lenticular galaxy.**

Treasures Northeast of the Veil Nebula

Object	Type	Mag(v)	Size/Sep	RA	Dec.
Lassell 1	Triple-double star	10.6–13.5	19″,22″,12″	21^h 34.8^m	+32° 05′
Abell 78	Planetary nebula	13.4	2.0′ × 1.7′	21^h 35.5^m	+31° 42′
NGC 7013	Lenticular ring galaxy	11.3	4.4′ × 1.4′	21^h 03.6^m	+29° 54′
Egg Nebula	Protoplanetary nebula	12.2	1.0′ × 0.5′	21^h 02.3^m	+36° 42′
NGC 7063	Open cluster	7.0	9.0′	21^h 24.5^m	+36° 30′
Baby Dumbbell	Planetary nebula	11.8	32″ × 20″	21^h 33.1^m	+39° 38′

Angular sizes and separations are from recent catalogs. Visually, an object's size is often smaller than the cataloged value and varies according to the aperture and magnification of the viewing instrument. Right ascension and declination are for equinox 2000.0.

core runs nearly north-south and shows subtle structure. I think it looks like a fat, squashed, indistinct Z, but images indicate that my eye is blending parts of the galaxy's interior ring and its nucleus. Can anyone with a large telescope discern this circumnuclear ring?

Now sweep 3.0° east from Lambda (λ) Cygni to the protoplanetary **Egg Nebula** (PK 80-6 1). Such nebulae are rare because they live for an astronomically brief time. When an aging star a little more massive than our Sun exhausts its hydrogen fuel, it sheds its outer layers while its core contracts. For a few thousand years, the cocoon of cast-off material simply reflects light from the star, and we see a protoplanetary nebula. As the collapsing star grows hotter, it eventually warms the nebula enough to emit its own light, and a planetary nebula is born.

The Egg Nebula is easily visible as a little fuzzy spot even in my 130-mm scope at 63×. It is elongated south-southwest to north-northeast and has a bright point within. At 117× the nebula appears 25″ long and half as wide. At 234× the brighter parts look like a little shoe print, with the heel (south) being smaller and considerably dimmer than the sole (north). The bright point noticed at 63× resides in the northern section.

The Egg Nebula's common name was bestowed by Mike Merrill due its oval appearance on the photographic prints of the *National Geographic Society-Palomar Observatory Sky Survey* (*S&T*: January 1975, page 21).

Farther east we come to the open cluster **NGC 7063**, 2.1° northeast of Upsilon (υ) Cygni. In my 130-mm refractor at 23×, it's a conspicuous little group of nine stars, most shining at 10th magnitude and arranged in an X with one bent leg. At 117× two of these stars prove to be doubles, and 10 more suns join this cute little group.

NGC 7063 is a youthful cluster like the Pleiades (M45) in Taurus, but it's more than four times as distant and thus appears much dimmer than its splashy cousin.

Our last target is the **Baby Dumbbell** (PK 86-8 1), which lies 3.0° east of Sigma (σ) Cygni. The tiny disk of this planetary nebula is visible in my 130-mm scope at 63×, and at 164× it appears brighter in the center with a very faint star off its southeastern side. At 234× it shows a slight east-northeast to west-southwest elongation and hints of fainter fuzz along the long sides. The nebula is bluish in my 10-inch scope at low power, while at 299× it's a fairly bright bar with a slightly pinched-in waist and faint extensions along its flanks. A narrowband filter enhances the bar a bit. This planetary gets its nickname from its resemblance to the much larger Dumbbell Nebula (M27) in Vulpecula.

When Night comes, let her open new wonders to your sight and see if you can find a favorite among them. ✦

***Sue French** welcomes questions at scfrench@nycap.rr.com. You can order her latest book,* Deep-Sky Wonders, *from Firefly Books at www.fireflybooks.com.*

NASA / HUBBLE HERITAGE TEAM / BILL SPARKS / RAGHVENDRA SAHAI

BERNHARD HUBL

Top: **The Egg Nebula has a complex structure that includes a thick dust band that obscures the central star together with shells of dust that were thrown off during the star's death throes. The source of the twin light beams is poorly understood. This false-color image uses red, green, and blue to indicate different polarizations of the reflected light.** ***Above:*** **The bright blue stars of NGC 7063 indicate that it's a young cluster.**

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▼ **CELESTRON CCD** Celestron unveils its Nightscape CCD Camera ($1,499), a new one-shot color camera for deep-sky imaging. This model features Kodak's 10.7-megapixel KAI-10100 color CCD sensor with 4.75-micron-square pixels in an array measuring 17.9 by 13.5 millimeters in a compact 4-inch-diameter housing. The Nightscape CCD Camera incorporates regulated thermoelectric cooling capable of reducing the sensor's temperature to as much as 20°C below ambient temperature, and an internal mechanical shutter that makes it a snap to record dark calibration frames. A full-frame image buffer allows you to simultaneously record a new image while downloading the previous one. Each purchase comes with Celestron's *AstroFX* camera-control and post-processing software, as well as drivers for *MaxIm DL*, an AC power supply, a 10-foot USB 2.0 cable, and a 2-inch-to-T-thread adapter.

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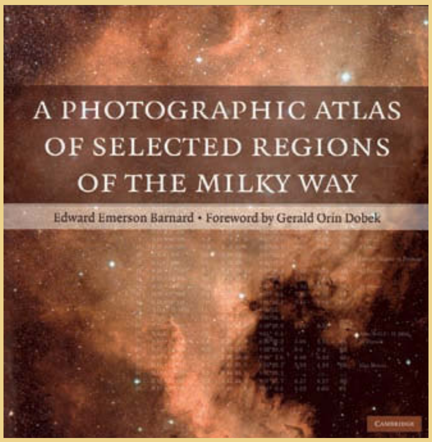

S&T: SEAN WALKER

BARNARD ATLAS One of the rarest 20th-century astronomy books, *A Photographic Atlas of Selected Regions of the Milky Way* by legendary astronomer Edward Emerson Barnard, has been reprinted. Astronomy professor Gerald Orin Dobek of Northwestern Michigan College has rearranged the original two-volume atlas into a single book. It begins with a foreword by Dobek, as well as an addendum detailing the reproduction of Barnard's original prints. The bulk of the new work, which is priced at $125, features each of Barnard's original 50 black-and-white plates, reordered to blend with matching charts compiled by Barnard and denoting objects listed in his famous catalog of dark nebulae. All of the author's original text is preserved, with slight editing and corrections. The book closes with a fold-out mosaic of all the plates assembled according to their proper galactic location. Cambridge University Press, 372 pages, ISBN 978-0-521-19143-2.

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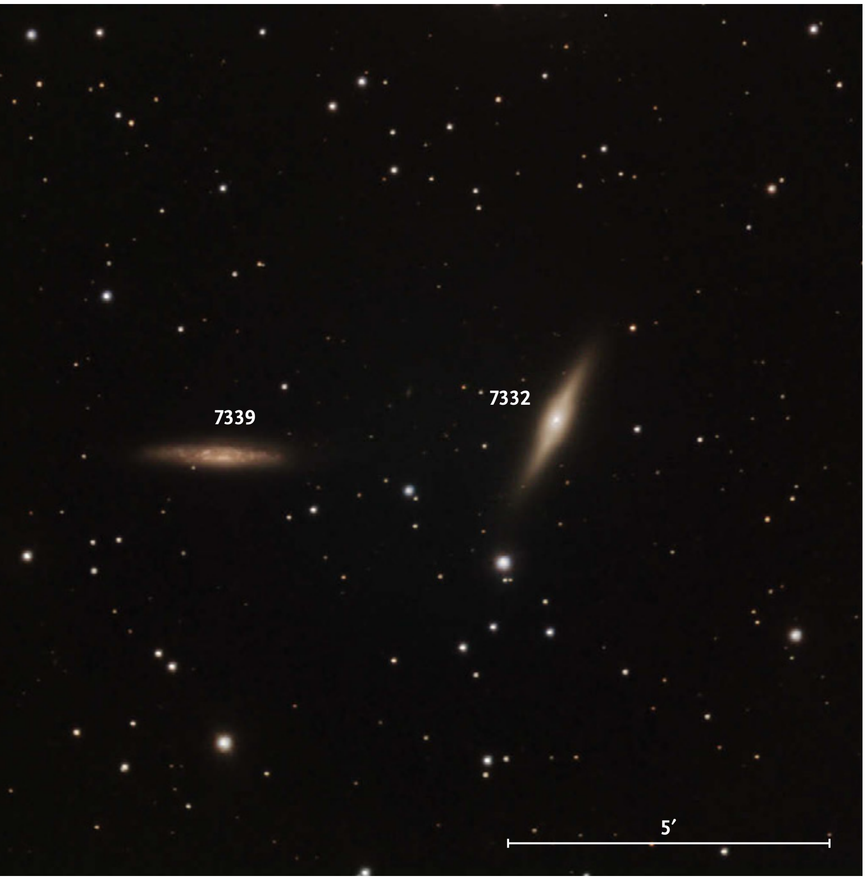
32 Avenue of the Americas, New York, NY 10013-2473, 212-924-3900, www.cambridge.org

Pretty Pegasus Pair

NGC 7332 and 7339 make a delightful galaxy duo.

AT THIS TIME of year I always revisit **NGC 7332** and **NGC 7339** in Pegasus. Although these edge-on galaxies are relatively close to Earth — about 60 million light-years — neither one is a marquee object. NGC 7332 glows at magnitude 11.1 with dimensions of 4.1′ × 1.1′. NGC 7339 is about one magnitude fainter and measures just 3.0′ × 0.7′. However, these fuzzy spindles are extremely close to each other, only 5.4′ apart. Their close proximity and similar-yet-different appearance definitely make this galaxy pair worth a closer look.

According to astronomers Doug Williams and Nigel Sharp, the Pegasus pair is a "dynamically isolated binary system," though the galaxies lie too far apart to exhibit obvious tidal interactions such as tails and streamers.

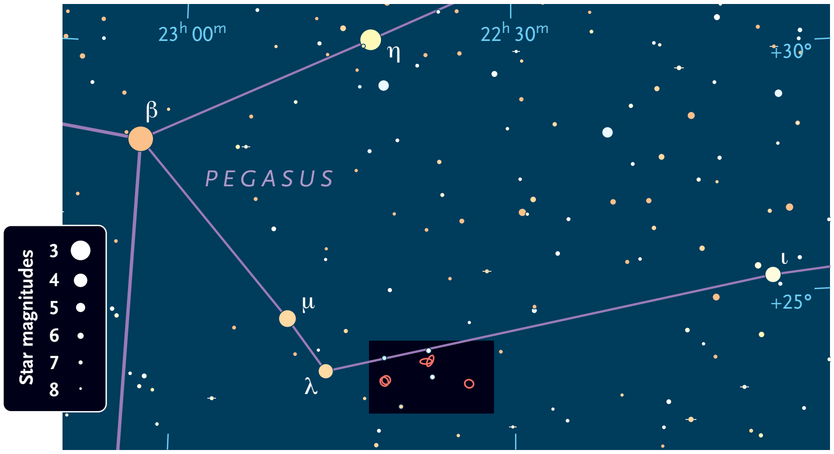


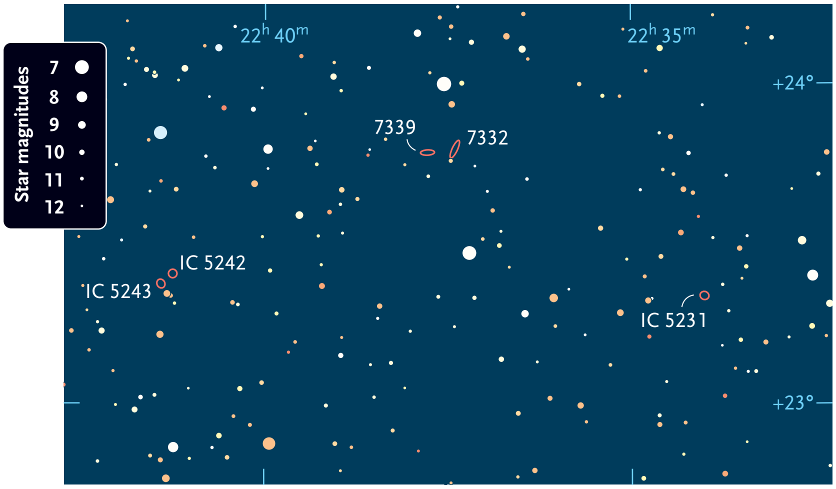
NGC 7332, classified S0 (pec), is a sleek lenticular galaxy with only partial dust lanes. Its most unusual feature is a bright, compressed, box-like central bulge, which accounts for the "pec" (peculiar) tag. By contrast, NGC 7339 is considered a spiral of type Sbc, though its slender profile makes classification difficult. NGC 7339 has a dusty disk and modest central bulge.

You'll find this attractive duo 2° west of 4th-magnitude Lambda (λ) Pegasi (see the chart on page 64). The galaxies float between two 7th-magnitude stars lined up north-south, 32′ apart. These glaring guardians — especially the one just 12′ north of the galaxies — are distracting at low to medium power. The solution, of course, is to exclude the stars from the field of view by zooming in closer. My 10-inch f/5.5 Dobsonian provides glare-free views starting at around 150×. This is sufficient magnification to reveal the galaxies as narrow masses oriented nearly at right angles to each other. A 12.6-magnitude star between the targets and an 11.0-magnitude star south of the brighter galaxy adds some sparkle to this charming celestial set piece.

For a more detailed view I employ my 17.5-inch f/4.5 Dobsonian and crank up the power. NGC 7332 responds well to magnification, thanks to its favorable surface brightness of magnitude 12.6 per square arcminute. The hoped-for features emerge at 222×: a small, bright, elongated core with a pinpoint nucleus, the central region flanked by a smooth, skinny halo tapered at both ends. Slanted north-northwest by south-southeast, the fuzzy lens aims roughly toward the 11th-magnitude star mentioned earlier. I agree with *Deep-Sky Wonders* columnist Sue French, who notes in her November 2007 column that the portion of the halo south of the nucleus appears longer than the opposite side. I detect no other features, even at magnifications over 400×.

NGC 7339 reclines east-west and thus points almost directly at NGC 7332. It plays second fiddle to its neighbor in every statistical category: visual magnitude (12.2), surface brightness (12.9), and size. Low power reveals a diffuse, cigar-shaped cloud that gradually brightens toward the middle. With increased magnification it's clear that the two ends of the galaxy are rounded, not tapered, and that the object's western half (the portion closest to



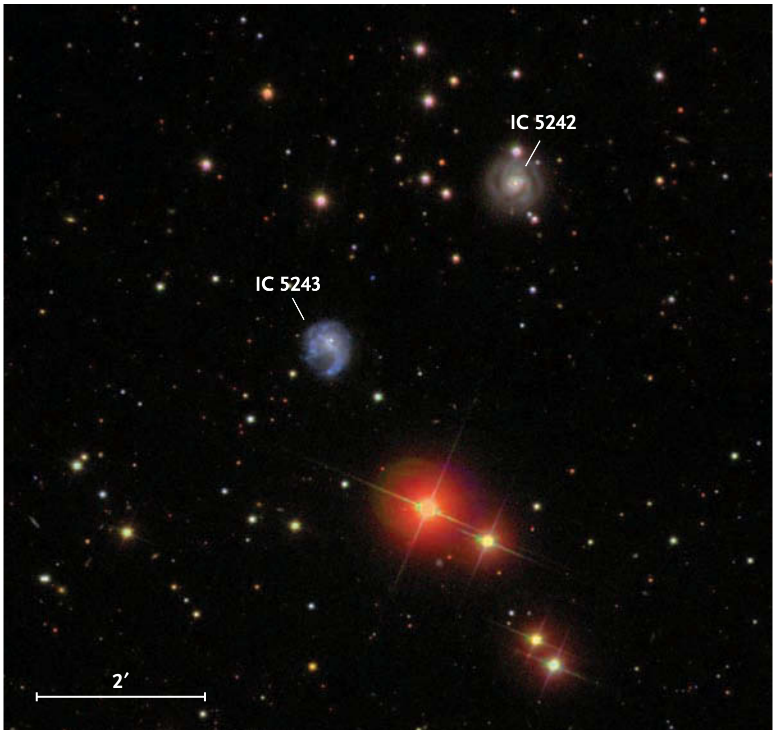


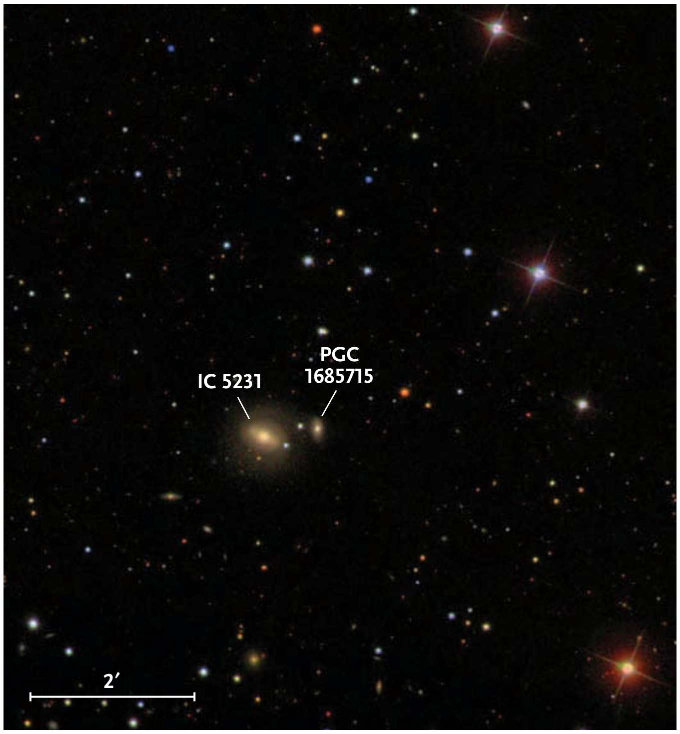
NGC 7332) looks somewhat brighter than the eastern half. I perceive a generally mottled texture and — in steady seeing — some dark knots on both sides. This eyepiece impression agrees with observatory images, which pick up several irregular lanes of dust across the galaxy.

Near the Pegasus pair are a few smudgy galaxies less than 1′ across that shine around magnitude 14. The brightest one, about 1° to the east-southeast, is **IC 5242**. It's attended by a 14th-magnitude star northward and another of 15th magnitude southwestward. Less than 3′ southeast of IC 5242, and (unfortunately) barely 2′ northeast of a 9.4-magnitude star, is **IC 5243**. By the numbers it should be the lesser of the two midgets. However, a bright center materializes at 285×, and to me this galaxy outshines its neighbor. Intriguingly, photos show IC 5243 to be a bluish galaxy of unusual structure, while IC 5242 is a loosely wound, face-on spiral.

Finally, almost 1° southwest of our main field is **IC 5231**. In my scope at 285×, this face-on barred spiral is teensy, round, and very faint overall — but sharply brighter at the center. Images show tandem 16th-magnitude stars in a northwest-southeast orientation off the galaxy's west flank. A truly miniscule blob, **PGC 1685715**, lies immediately west of the northwest star. This compact grouping of two galaxies separated by two stars — all at the threshold of vision — should be a fun challenge for owners of very large Dobsonians. ✦

Ken Hewitt-White pursues deep-sky objects every summer and fall from the mountains of southern British Columbia.





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Gary Seronik
Telescope Workshop

Rough Grinding the Easy Way

Say goodbye to the drudgery of hogging out a curve in your mirror blank.

I REMEMBER HEARING famed telescope guru John Dobson proclaim, “Mirror making is caveman work — eat well, sleep well, and work like hell!” And there’s little doubt that the most caveman-like part of the process is rough grinding. That’s the stage in which you carve the initial curve into the surface of a glass blank. The traditional approach is to use lots of coarse abrasive (usually #80 or #60 carborundum) and plenty of muscle power. Depending on the size of the mirror and its focal ratio (which determines the depth of the curve), rough grinding can take many long hours. And if you have to prepare multiple blanks, the task can be daunting.

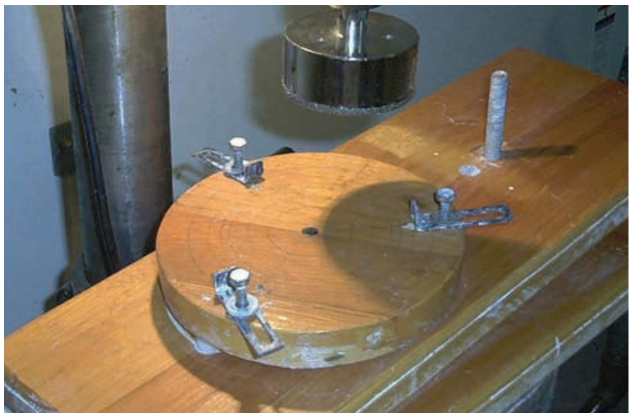
Such was the situation facing telescope maker David Groski in advance of the annual Delmarva Mirror Making Seminar in Maryland. Dave had to prepare several blanks for attendees and he needed a faster way to rough grind the curves. He decided to machine generate the blanks the way professional optical fabricators do. His approach is simplicity itself and worth considering even if you’re only going to make one or two mirrors. “It takes around 30 to 45 minutes to cut an f/4 curve in a 10-inch mirror and about the same amount of time to cut the corresponding curve on the glass tool,” Dave notes. “If you were to grind it by hand it would take six hours at least, and most likely much longer.”

The equipment requirements are minimal. You need a drill press — a piece of gear found in virtually every home workshop. You also need a diamond coring bit such as the ones available from THK Diamond Tools, which has an online store on eBay. The bits cost around $30 (depending on the size). Lastly you’ll need to fix the glass disk to some kind of turntable with a fine tilt adjustment. If the table on your drill press allows for precise tilt adjustments, you only need to mount a simple turntable to it and you’re up and running. But more likely you’ll need to make what Dave refers to as a “sine table,” shown in the photographs here. The tilt of the glass blank is precisely set by adjusting a nut and bolt at the far end of the table.

To generate a concave curve for a mirror, you position the blank under the coring bit so that the edge of the bit just touches the center of the glass blank. For a convex curve, the bit just touches the outer edge of the glass. The bit needs to be at least half the diameter of the glass disk, but it can be larger. For example, a 5-inch-diameter bit will suffice for mirrors up to 10 inches in diameter.

Crucial to the process is calculating the correct amount of tilt to generate a curve of the necessary depth for your mirror and tool set. The sine of tilt angle is the diameter of the coring bit divided by two times the radius of curvature of the mirror, or tool. For example, let’s say

DAVID GROSKI (2)



Left: **Machine generating the curve in a mirror blank using the arrangement shown here can greatly shorten the time it takes to make a telescope mirror. Only three components are involved: a drill press, a diamond coring bit, and a home-built tilt table.** ***Right:*** **David Groski’s “sine table” allows him to precisely set the tilt angle of the glass blank so that the diamond bit produces a curve of the desired depth. Three adjustable cleats hold the glass blank in position on the turntable.**

you're using a 5-inch bit to generate an f/4.5 curve in a 10-inch mirror. The mirror's radius of curvature is 90 inches and requires that the table be tilted 1.59° — the angle with a sine of 5/(2×90). You can look up the angle in a trig table, or use a scientific calculator's arcsine key.

How do you achieve such a tiny, precise tilt? This is where the sine table comes in. "I set the table to the angle I need by using simple trig and measuring a known distance from the hinge," Dave explains. "Then I set the vertical height by adjusting the set screw until I achieve the correct angle. This gets me close to the radius I want, but I use a spherometer or template to measure the curve after I make the cut and, if needed, adjust the angle and take a second pass."

To generate the curve, set the drill press at its slowest speed (under 100 rpm) and lower the spinning bit until it engages the surface of the glass. As glass is ground away, you continuously, slowly rotate the mirror with the turntable (it may turn on its own), all the while ensuring that the mirror and bit are kept moist to prevent dangerous glass dust from becoming airborne. Grinding continues until the bit has ground the full diameter of the glass and the curve extends from center to edge.

The curves for both the mirror and its matching tool should be generated in succession without changing the angle of the sine table. It's especially important to ensure that the mirror's bevel doesn't wear down and cause edge chipping. Dave finishes off the process by grinding the mirror against the tool with a few wets using #80 grit. "In most cases," he notes, "the curves generated with the drill press will be close enough that some grinding with #80 will quickly get me to the curve I want. And because I need to mate the tool to the mirror, there's no reason to try to get things dead perfect when initially generating the curves by machine."

Readers wanting to know learn more can contact Dave at groski@udel.edu. ✦

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*Contributing editor **Gary Seronik** has made numerous mirrors and is about ready to give up his caveman ways. Some of his scopes are featured at his website, www.garyseronik.com.*

GHOST STORIES ON STORMY NIGHTS Left to right: Percy Bysshe Shelley (1792–1822), Claire Clairmont (1798–1879), John Polidori (1795–1821), Mary Shelley (1797–1851), and Lord Byron (1788–1824) gathered at Villa Diodati on the shores of Lake Geneva, Switzerland, in June 1816. Their evening ghost stories would provide the creative spark that led Mary Shelley to conceive the idea for *Frankenstein*, a landmark novel that has gained in popularity and stature since its publication in 1818. Byron and Percy Shelley are widely regarded as two of the greatest poets in the English language. Polidori was a physician and writer who authored the 1819 short story *The Vampyre*. Clairmont was Mary's stepsister and Byron's mistress.

Illustrations by Leah Tiscione unless otherwise credited

The Moon & the Origin of Frankenstein

DONALD W. OLSON • MARILYNN S. OLSON • RUSSELL L. DOESCHER • AVA G. POPE • KELLY D. SCHNARR

An astronomical investigation may have solved a lingering mystery surrounding the origin of the classic horror novel.

On dark and stormy nights in June 1816, as jagged lightning bolts filled the sky and thunder echoed from nearby mountains, a group that included famous (and soon-to-be-famous) writers gathered to tell ghost stories around the fireplace of Villa Diodati, overlooking Switzerland's Lake Geneva. Present were two of England's greatest poets, Lord Byron and Percy Bysshe Shelley, along with Mary Shelley (then 18 years old), Mary's stepsister Claire Clairmont, and the physician John Polidori. Byron and Polidori lived in Villa Diodati, while the Shelley party rented a nearby house called Maison Chappuis.

During one of the evenings in Diodati, Mary Shelley (1797–1851) first offered her tale of *Frankenstein* — an iconic creation that has inspired classic horror films and countless pop-culture references. In Shelley's novel, scientist Victor Frankenstein brings to life a monster made of cadaverous remains, who goes on a murderous rampage when his creator refuses to ease his loneliness by producing a mate.

Surprisingly, the question of when Mary Shelley conceived this idea has been a long-standing matter of controversy, with some scholars even calling Mary's honesty into question. Because Mary's published recollections include her memory of moonlight outside her bedroom window, we wondered whether this astronomical reference might allow us to test the accuracy of her account and determine a precise date for the origin of *Frankenstein*.

Mary Shelley's Account

Our most important clue came from Mary Shelley's Introduction to the 1831 edition of *Frankenstein*, which describes how such "a young girl" could conceive, in her words, "so very hideous an idea:"

In the summer of 1816, we visited Switzerland, and became the neighbours of Lord Byron ... it proved a wet, ungenial summer, and incessant rain often confined us for days to the house. Some volumes of ghost stories ... fell into our hands.

At first the group read the published tales aloud, but Mary recalled that Byron suggested that they should each try to write their own ghost story:

I busied myself to think of a story ... one to make the reader dread to look round, to curdle the blood, and quicken the beatings of the heart ... I thought and pondered — vainly ... Have you thought of a story? I was asked each morning, and each morning I was forced to reply with a mortifying negative.

After several days of embarrassment, a talk around the fireplace gave Mary the spark of an idea:

... various philosophical doctrines were discussed, and among others the nature of the principle of life ... Night waned upon this talk, and even the witching hour had gone by, before we retired to rest. When I placed my head on my pillow, I did not sleep ... My imagination, unbidden, possessed and guided me

THE BODLEIAN LIBRARIES, UNIVERSITY OF OXFORD, SHELLEY RELICS (D)

THE AUTHOR This posthumous portrait of Mary Shelley depicts the author of *Frankenstein* sometime after her husband, Percy Bysshe Shelley, died in 1822 (he passed away just six years after the summer at Lake Geneva). Mary Shelley was only 18 years old when she conceived the idea for her most famous work. The artist Reginald Easton is said to have created this portrait from Mary Shelley's death mask, so this is probably a reasonably accurate portrayal.

... I saw the pale student of unhallowed arts kneeling beside the thing he had put together. I saw the hideous phantasm of a man stretched out, and then, on the working of some powerful engine, show signs of life ...

As she returned to reality, Mary noticed that moonlight was shining through her bedroom window:

I wished to exchange the ghastly image of my fancy for the realities around. I see them still; the very room, the dark parquet, the closed shutters, with the moonlight struggling through, and the sense I had that the glassy lake and white high Alps were beyond ...On the morrow I announced that I had thought of a story ... a transcript of the grim terrors of my waking dream.

Mary Shelley began to develop her story into the novel *Frankenstein*. Lord Byron and Percy Shelley soon lost interest in the ghost-story project, but Polidori later developed a fragment from Byron into a novel titled *The Vampyre*. This book helped to inspire similar tales throughout the 19th century, culminating with Bram Stoker's famous story. Thus horror's two most enduring characters — Frankenstein's monster and Count Dracula — both trace their origins back to the storytelling evenings in Villa Diodati.

Was Mary Shelley Dishonest?

The precise dates for Byron's suggestion and for Mary's "waking dream" remain controversial. The chronology is

COLLECTION OF DONALD OLSON

SUMMER RESIDENCES This postcard from around 1900 shows Villa Diodati overlooking Lake Geneva. Maison Chappuis no longer exists, but its location is marked. Both buildings are located on a steep slope that afforded relatively clear views to the west, but the hill obstructs the eastern horizon. This basic topography was an important clue in the authors' investigation.

based primarily on the journals and letters written by the party during their stay in Switzerland. Despite the lack of compelling evidence, the overwhelming majority of scholars conclude that Byron made his ghost-story proposition on June 16th. The meager evidence comes from the June 16th entry from Polidori's diary, which mentions that the entire group spent the night at Villa Diodati:

June 16 • *Shelley came, and dined and slept here, with Mrs. S[helley] and Miss Cla[i]re Clairmont ...*

Polidori's diary entry for the following night implies that Mary had begun her story with all the others (except Polidori himself):

June 17 • *The ghost-stories are begun by all but me.*

Therefore, identifying June 16th as the night of Byron's proposal, and with the ghost stories beginning the following evening, conflicts with Mary Shelley's detailed description of how she agonized for several days — not just a few hours — while trying to come up with a story. Scholars have long considered this apparent inconsistency a stumbling block to accepting her account.

Some scholars dismiss Shelley's version of the origin of *Frankenstein* as a romantic invention. One of the harshest criticisms of her 1831 Introduction comes from an article by James Rieger (*Studies in English Literature*, 1963):

The received history of the contest in writing ghost-stories at Villa Diodati during the "wet, ungenial" June of 1816 is well known to every student of the Byron-Shelley circle. It is, as we shall see, an almost total fabrication ... No statement in her account of the writing party at Diodati, or even of the inception of her own idea, can be trusted ... the entire chronology of conception is altered.

A biography by Miranda Seymour (*Mary Shelley*, 2000) concludes that Mary's account is simply a lie:

She wrote the 1831 Preface in order to help sell the book; telling the best possible story mattered more than the truth.

Other authors have tried to produce a chronology consistent with Mary's account by including a delay of several days between Byron's ghost-story suggestion and Mary's "waking dream" that gave her the idea for *Frankenstein*. These scholars still place Byron's proposition on June 16th and then assign Mary's "waking dream" to the early morning of June 22nd, hours before the fireside group temporarily broke up as the weather improved and Byron and Shelley left to sail around the lake. An article by Burton Pollin (*Comparative Literature*, 1965) advances this theory:

On June 16 the group read aloud a collection of ghost stories ... Byron then suggested that each one write a ghost story ... it must be assumed that her tale first took the shape of her hideous dream, described in the preface, just before Shelley and Byron departed on their tour of Lake Leman [Lake Geneva] ...

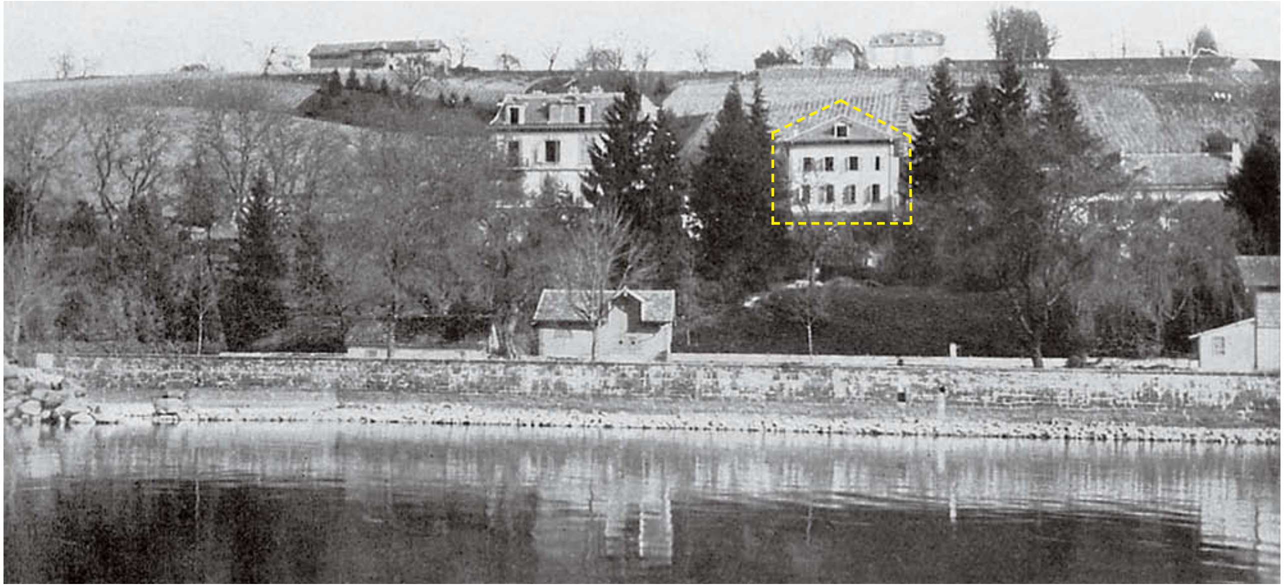
ROGER SINNOTT

MARILYNN OLSON

THE AUTHORS AT VILLA DIODATI ***Top:*** **Coauthors Ava Pope, Kelly Schnarr, and Don Olson stand in front of the building where the Byron-Shelley party exchanged ghost stories.** ***Above:*** **Russell Doescher and Ava Pope examine a topographical map in the garden of Villa Diodati.**

Volcanic Skies

A volcano played a role in the stormy weather that accompanied the origin of *Frankenstein*. Mount Tambora in the Dutch East Indies (now Indonesia) had exploded in April 1815, and the cloud of ash, dust, and aerosols from this catastrophe, one of the largest volcanic eruptions in historic times, affected weather worldwide for several years. The year 1816 became known as the "year without a summer," with cold temperatures and nearly constant rain that drove the Byron-Shelley group indoors.



COLLECTION OF DONALD OLSON

SHELLEY RESIDENCE Mary Shelley had her "waking dream" while sleeping at Maison Chappuis (outlined), just a short walk downhill from Villa Diodati. Maison Chappuis no longer exists, but the two nearby buildings on its left in this 1880s photo are still there.

When Did the Ghost Stories Begin?

Although most modern authors adopted June 16th as the probable date for Byron's ghost-story proposition, we realized that Polidori's diary has no description of Byron making his original suggestion, and a specific date appears nowhere in the primary sources.

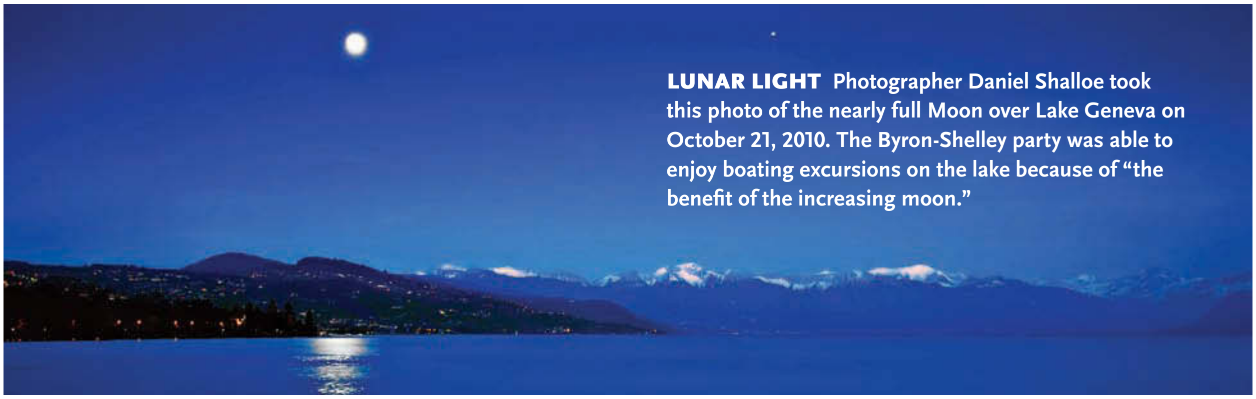
Paula Feldman and Diana Scott-Kilvert, the editors of Mary Shelley's journals, recognize this dating uncertainty and cautiously state that "Byron proposed that they should each produce a ghost-story" at "some time" after "10 June, when Byron and Polidori moved into Villa Diodati" (*The Journals of Mary Shelley*, 1987).

Based on the surviving letters, journals, and memoirs, Byron's proposal appears to fall between June 10th and June 16th. Mary Shelley's astronomical reference in her 1831 Introduction might help to resolve the dating controversy. Mary noticed the moonlight outside her bedroom window at the point in her waking dream when she imagined the monster confronting his sleeping creator:

He sleeps; but he is awakened; he opens his eyes; behold the horrid thing stands at his bedside, opening his curtains, and looking on him with yellow, watery, but speculative eyes.

I opened mine in terror ... I wished to exchange the ghastly image of my fancy for the realities around. I see them still; the very room, the dark parquet, *the closed shutters, with the moonlight struggling through ... (*Frankenstein*, 1831 edition)*

This waking dream became a moonlit scene in her novel. So far as we know, no previous scholars have used this astronomical clue, yet Mary's use of other natural phenomena suggests that her lunar reference should be taken seriously. For example, she witnessed a spectacular thunderstorm over Lake Geneva on June 13th, vividly described the storm in a letter, and later copied this passage almost verbatim in *Frankenstein*. Mary's "moonlight" may likewise have been derived from a real event.



DANIEL SHALLOE

LUNAR LIGHT Photographer Daniel Shalloe took this photo of the nearly full Moon over Lake Geneva on October 21, 2010. The Byron-Shelley party was able to enjoy boating excursions on the lake because of "the benefit of the increasing moon."

Trip to Switzerland

On which nights in June 1816 could bright moonlight have shone on Mary Shelley's bedroom window after midnight (after "the witching hour had gone by")

To answer this question, our Texas State University group traveled in August 2010 to the town of Cologny, about two miles northeast of downtown Geneva. Villa Diodati still stands on a steep slope overlooking the lake, facing west. Maison Chappuis no longer exists, but archival photographs show its exact location lower down on the slope. Windows of both houses afforded relatively clear views to the west, but the hill on which the houses stood partially blocked the view of the eastern sky. From our GPS measurements of distances and elevations, we determined that the hill's average slope is 15°.

Combining this topographical information with calculations of the Moon's phase and position allows us to rule out the chronology suggested by authors who assign her "waking dream" to June 22nd. During the hours before morning twilight on June 22, 1816, the Moon was a waning crescent, only 13% lit, and the hill on which both houses stood would have blocked her view to the east of the rising Moon. Moonlight could not have fallen on Mary's bedroom window in the pre-dawn hours on June 22nd.

But we can suggest an earlier date, consistent with Mary's 1831 account. Three lunar references in the primary source material show us that the group members were interested sky observers, which helps to strengthen our argument.

1. In a letter started in the second half of May 1816 and continued at intervals over the next two weeks, Mary mentions boating on Lake Geneva in the moonlight:

... every evening at about six o'clock we sail on the lake ... Twilight here is of short duration, but we at present enjoy the benefit of an increasing moon, and seldom return until ten o'clock ...

Polidori's diary entries on May 30th and 31st, and June 2nd, give us precise dates for several of these evening excursions, with the June 2nd entry specifically stating "a circular dome bespangled with stars only and lighted by the moon which gilt the lake."

At 9 p.m. on the evenings of May 30, May 31, and June 2, 1816, the Moon was a waxing crescent, with an illuminated fraction of 15%, 24%, and 46%. This is consistent with Mary's mention of an "increasing moon." Sunset was at about 7:45 p.m., and moonset occurred after 11 p.m. on each of these dates, in good agreement with the descriptions by both Mary Shelley and Polidori.

2. Another Polidori diary entry from a week later makes a passing remark about the Moon:

June 9 • ... came home. Looked at the moon, and ordered packing-up.

On June 9, 1816, the Moon was more than 99.9% illuminated as it rose over Mont Blanc at about 8 p.m., explaining why it caught Polidori's eye. Polidori's mention of "packing-up" refers to the impending move with Byron from their temporary hotel lodgings, as mentioned in the next day's diary entry:

June 10 • ... Got things ready for going to Diodati ... went to Diodati ... Shelley etc. came to tea, and we sat talking till 11 ...

Byron's suggestion to write ghost stories could have occurred between June

The Time System in 1816

The clock times in this article are expressed in local mean time, which at Cologny (6° 11′ east longitude, 46° 13′ north latitude) is 25 minutes ahead of UT. Modern time zones were not employed until the late 19th century.

Proposed 1816 Chronology

May 27	New Moon
May 30 to June 2	Boating on the lake in the evenings by the light of an "increasing moon"
June 3	First-quarter Moon
June 9	Polidori observes the nearly full Moon.
June 10	Full Moon; Byron and Polidori move into Villa Diodati.
June 10 to 13	Byron proposes ghost stories on one of these evenings; Mary Shelley is initially unable to think of a story.
June 13	Spectacular thunderstorm over Lake Geneva
June 15	Evening conversation at Villa Diodati about the principle of life
June 16	The origin of *Frankenstein*: Mary Shelley's "waking dream" (between 2:00 and 3:00 a.m.) with light from a waning gibbous Moon struggling through the closed shutters. That evening Mary Shelley begins to tell her story at Villa Diodati.
June 17	Third-quarter Moon; all group members except Polidori have begun their stories.
June 22	Byron and Percy Shelley depart to tour Lake Geneva.
June 25	New Moon

THE MONSTER One of fiction's most enduring characters is the monster in Mary Shelley's novel *Frankenstein*. People often erroneously assume that the monster's name is Frankenstein; in fact, that's the name of the scientist who created the monster. Shelley did not give the monster a name.

10th (the first evening in Villa Diodati when the group gathered around the fireplace) and about June 13th (the night of the spectacular storm). This allows several days for Mary's struggle to think of a story. Polidori's diary mentions that the combined Byron-Shelley group met at Diodati on June 15th:

June 15 • *Shelley etc. came in the evening ... a conversation about principles, — whether man was to be thought merely an instrument.*

This conversation may have included the discussion of the "principle of life" that sparked Mary's idea.

Mystery Solved?

3. Mary Shelley's "waking dream" that inspired *Frankenstein* could therefore have occurred in the early morning hours of June 16, 1816. A bright waning gibbous Moon, 67% lit, rose into the southeastern sky that night. Planetarium programs for Cologny give the time of moonrise as 12:01 a.m. on June 16th, but this calculation assumes a flat horizon. The Moon actually would not have cleared the 15° slope until just before 2 a.m. and then could have illuminated her bedroom window in Maison Chappuis. This calculated time is in good agreement with Mary Shelley's description that "the witching hour had gone by ... the closed shutters, with the moonlight struggling through ..."

Because June 16th was only five days before the summer solstice, with civil twilight beginning at 3:29 a.m. and sunrise at 4:07 a.m., the brightening sky would have overpowered the moonlight by roughly 3 a.m. Our calculations thus suggest that Mary Shelley's "waking dream" occurred between 2 a.m. and 3 a.m. on June 16, 1816.

If moonlight had not been shining on her window that morning, the astronomical analysis would point to a fabrication on her part. Instead, the bright waning gibbous Moon, together with the chronology we suggest, supports the idea that Mary Shelley's 1831 Introduction provided a generally accurate account of *Frankenstein*'s origin.

Mary Shelley gave us an icon that resonates today even more than it did before science and invention so radically changed our world. As Halloween approaches, it's appropriate to look back at the most famous monster of them all — created in the terrifying dream of an 18-year-old woman on a moonlit night on the shores of Lake Geneva. ✦

To view more images related to this article, visit SkyandTelescope.com/Frankenstein.

Don Olson and Russell Doescher teach in the Department of Physics, and Marilynn Olson in the Department of English, at Texas State University, where Kelly Schnarr is an undergraduate in the Department of Education and the Honors Program. Ava Pope recently received her B.S. from Texas State and is now a physics graduate student at the University of North Carolina. *The authors are grateful for research assistance from Charles Robinson (University of Delaware) and Margaret Vaverek (Texas State University).*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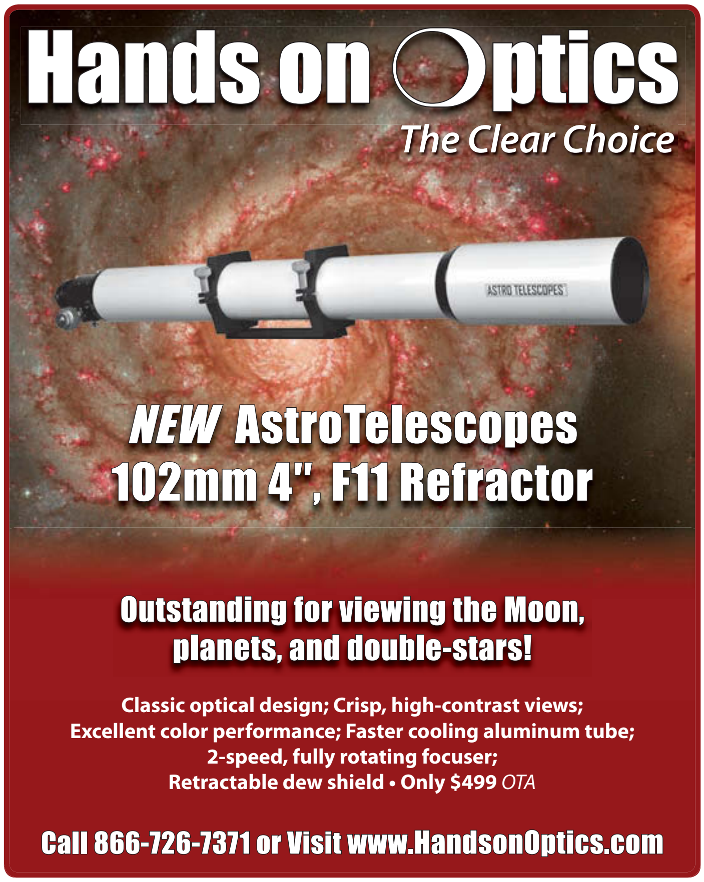
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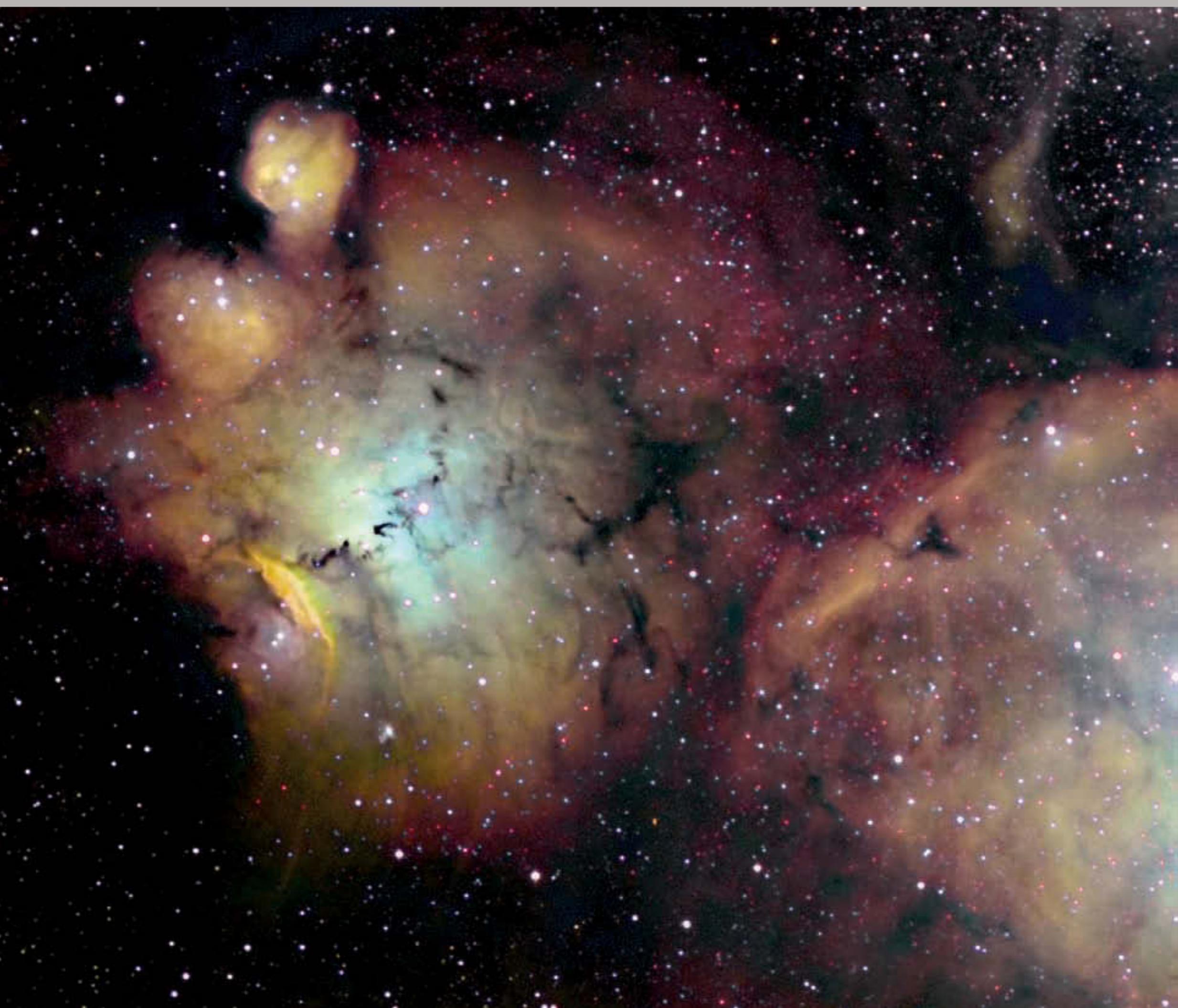
▸ **WHIRLPOOL SURPRISE**
R. Jay GaBany
Supernova 2011dh flared up in spiral galaxy M51 in early June. The explosion appears in the outer spiral arm at the bottom-right of this colorful image.
Details: *RCOS 20-inch Ritchey-Chrétien telescope with an Apogee Alta U16M CCD camera. Total exposure was 12⅓ hours through Astrodon color filters.*

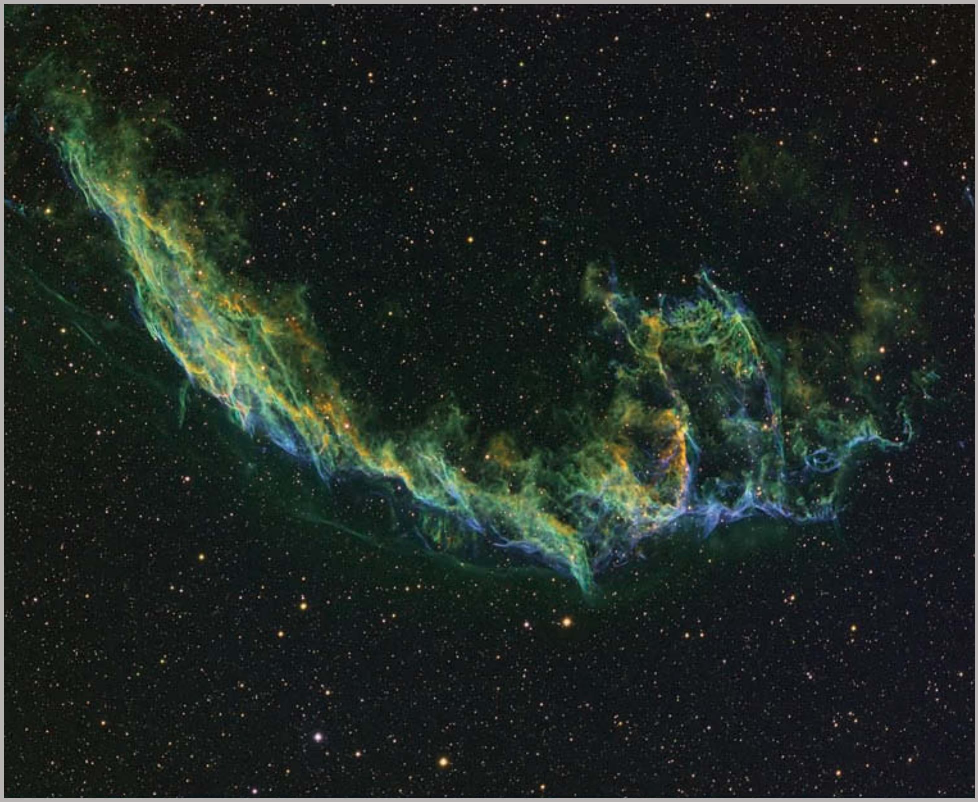
Visit SkyandTelescope.com/gallery for more gallery online.



SHARPLESS TRIO
Michael Caligiuri
East of the famous Lagoon Nebula resides NGC 7559, a beautiful combination of emission and reflection nebulosity. This false-color image highlights the interplay of ionized hydrogen, sulfur, and oxygen atoms around a dark, meandering dust lane.
Details: *Takahashi FSQ-106N with an SBIG ST-10XME CCD camera. Total exposure was more than 4 hours through Astrodon narrowband filters.*

▲ **NOCTILUCENT DELIGHT**
Don Thacker
During the pre-dawn hours of July 4th, Don Thacker of Edmonton, Alberta, was treated to this spectacular display of noctilucent clouds.
Details: *Canon PowerShot SX20 IS digital camera with zoom lens at 5 mm. Total exposure was ⅛ second at f/2.8, ISO 800.*

► **EASTERN SHOCK FRONT**
Craig & Tammy Temple
The Eastern Veil Nebula, with brighter areas cataloged as NGC 6992 (left) and 6995 (right), is a portion of a large supernova remnant thought to have originated some 8,000 years ago.
Details: *Stellarvue Raptor SVR105-3SV apochromatic refractor with QSI 583wsg CCD camera. Total exposure was more than 11 hours through Astrodon narrowband filters.*



▶ **JOVIAN ESCORTS**

Brad Hill

On a particularly steady morning last June 27th, Brad Hill of Nashville, Tennessee, captured numerous tiny eddies and swirls in Jupiter's newly returned South Equatorial Belt, as well as details on the planet's moons Io (right) and Ganymede (bottom right). South is up.

Details: *Celestron C14 Schmidt-Cassegrain telescope with Point Grey Research Flea3 video camera. Stack of 3,200 frames each of red, green, and blue recorded through Astronomik color filters.*

▶ **WINGED DUMBBELL**

Emil Ivanov

Popularly known as the Dumbbell Nebula, planetary nebula M27 in Vulpecula hardly bears a resemblance to its popular nickname in long exposures such as this colorful example.

Details: *12-inch ASA Newtonian astrograph with an SBIG STL-11000M CCD camera. Total exposure was 15 hours through Baader narrowband and Astronomik color filters.*

▼ **SPOTTED SUN**

Babak Tafreshi & Gernot Meiser

August brought observers the welcome treat of the large sunspot groups (left to right) 1263, 1262, and 1261, each easily visible through a solar filter.

Details: *Meade 10-inch RCX400 Schmidt-Cassegrain telescope with a Canon EOS 5D DSLR camera. Snapshot recorded through a glass solar filter.* ✦

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When it's time for transit viewing, go where the pros go — Mauna Kea, with *Sky & Telescope.* Reserve your adventure now by visiting http://InSightCruises.com/Transit or call InSight Cruises at 650-787-5665. Aloha!

DAY 1: June 3

Arrive Kona

Upon your arrival at Kona, you'll grab a taxi to our hotel and conference center, the luxurious Waikoloa Beach Marriott Resort & Spa. This evening there will be a welcome reception (7pm) where you will enjoy cocktails and light hors d'oeuvres.

DAY 2: June 4

Full Day of Classes Waikoloa Beach Marriott

Learn all about Transits of Venus, past and present, from *Sky & Telescope* Editor Robert Naeye. He and other famous astronomy speakers will be delivering several talks over the next couple of days. In addition to the talk described below, other scheduled talks include:

- The Hubble Space Telescope's Greatest Scientific Achievements
- The Asteroid Impact Threat
- Cassini at Saturn, Part 1: The Planet & Rings
- Cassini at Saturn, Part 2: The Moons

DAY 3: June 5

Transit Day — Welcome to the Keck Observatory

Today we climb Mauna Kea to the summit, to the Keck Observatory (pictured above), at nearly 14,000 feet of elevation, to observe the transit. Above the cloud ceiling we're practically guaranteed to have clear skies and a perfect view. For those sensitive to very high altitude, we will also be observing from the Mauna Kea VIS (aka Onizuka Visitor's Center) at 9,300 feet.

The day's itinerary:
- 10:00am: Depart Waikoloa Beach Marriott
- Noon: Arrive VIS, picnic lunch served
- 12:10pm: Venus first touches the Sun
- 1:00pm: Group departs VIS for the Observatory on Mauna Kea
- 4:00pm: Afternoon snack
- 6:45pm: Transit ends, group departs VIS
- 8:15pm: Return to Marriott
- 8:30pm: Celebration reception and dinner

DAY 4: June 6

Keck Headquarters

This morning we take a 30-minute bus drive to the Keck Observatory headquarters in Waimea. We'll hear two lectures by prominent astronomers, "scope out" the Keck telescopes on the Mauna Kea summit (through a telescope in the lobby of the headquarters), and spend some quality time in the unique gift shop.

The day's itinerary:
- 8:30am: Depart Waikoloa Beach Marriott Resort
- 9:00am: Arrive at Keck Observatory HQ for two 90-minute presentations and tour
- 12:30pm: Depart Keck Observatory HQ
- 1:00pm: Arrive at Waikoloa Beach Marriott Resort
- Relaxed afternoon on the Resort property

DAY 5: June 7

Fly Home

Depart from KOA Airport

Optional Tour to the 'Imiloa Astronomy Center

'Imiloa Astronomy Center of Hawai'i is an astronomy and culture education center located in Hilo, Hawaii. It features exhibits and shows dealing with Hawaiian culture and history, astronomy (particularly at the Mauna Kea Observatories), and the overlap between the two. (June 8)

Itinerary for The 'Imiloa Astronomy Center:
- 8:30am: Depart Waikoloa Beach Marriott Resort
- 10:00am: Arrive at 'Imiloa Astronomy Center for a private "insiders" presentation, a planetarium show, and time to roam the exhibits
- 12:30pm: Lunch in Hilo
- 3:00pm: Depart the 'Imiloa Astronomy Center
- 4:30pm: Arrive at Waikoloa Beach Marriott Resort
- Farewell cocktail party

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What's included: ▪ Four hotel nights (including all taxes) ▪ Six educational classes ▪ Round-trip transportation to the summit of Mauna Kea ▪ Round-trip transportation to the Keck Observatory headquarters in Waimea ▪ Lunch and snack on Mauna Kea on June 5 ▪ Arrival cocktail party on June 3 ▪ Celebration cocktail reception and dinner at the Marriott on June 5.

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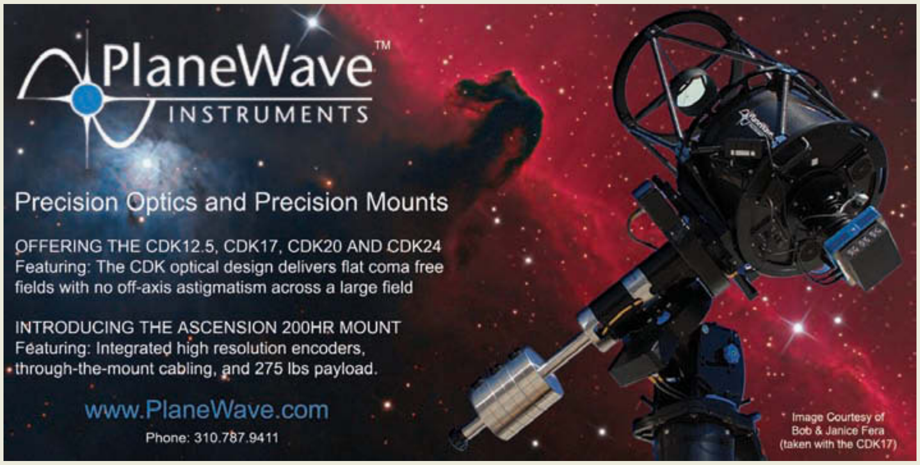

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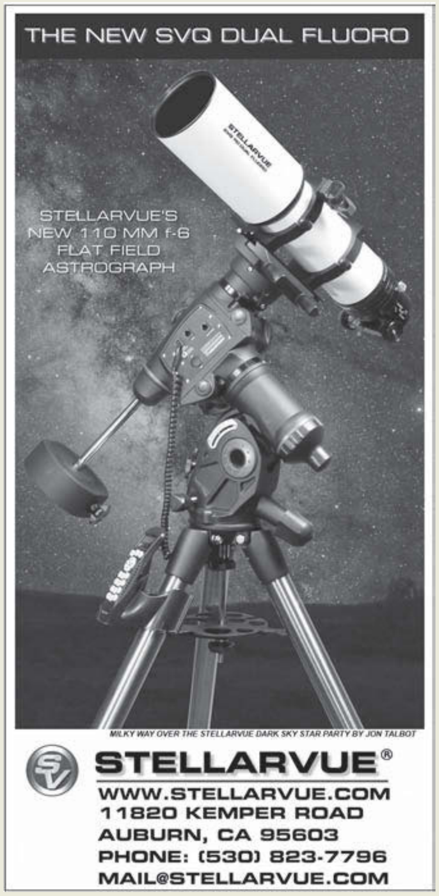

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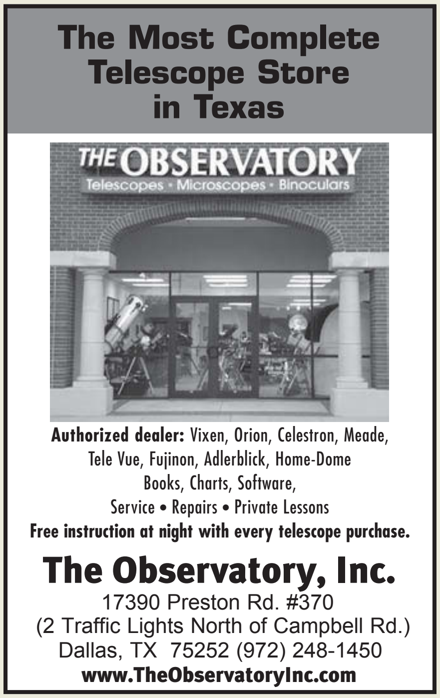

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IN THE NEXT ISSUE

The Next Mars Rover

If you think Spirit and Opportunity are great, wait until NASA's Mars Science Laboratory starts exploring the Red Planet.

Amateur on a Mission

An Illinois amateur astronomer built 24- and 32-inch telescopes to bag asteroids, and he's nearly finished constructing a 50-incher.

Producing Natural-Color Images

An astrophotographer shares her technique for creating natural-color astrophotos using a variety of filters.

Deep-Sky Binoculars

What makes one pair of binocs better than another, and one target object better than another?

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Eyewitness to History

A former S&T *editor in chief reflects on 70 years of transformative change in astronomy.*

Quasars. Brown dwarfs. Dark energy. Exoplanets. Radio galaxies. Coronal mass ejections. Dark-matter halos. The Kuiper Belt. Mars's Tharsis Bulge. Pulsars. Microwave background radiation. X-ray binaries. Cosmic voids. Gamma-ray bursts. Have you figured out what these celestial objects and phenomena have in common? All are part of the modern lexicon of astronomy, but not one of them was known when the first issue of *Sky & Telescope* rolled off the press in November 1941.

My mentor and predecessor at *S&T*'s helm, the late Leif J. Robinson, used to call the magazine "the living history of astronomy." Looking back from the vantage of its 70th birthday, and paging through some of the 839 issues on my bookshelf, I can say he was right. Month after month, year after year, decade after decade, *S&T* has chronicled the quest to explore and understand the universe around us, often in the words of the very people whose discoveries and inventions made readers' eyes widen with awe and wonder.

When I meet people who tell me they've been reading *S&T* since the very first issue, I marvel at how much astronomy has changed in their lifetimes. In 1941 we thought we lived in a universe dominated by stars and galaxies. Now we think that everything that was known seven decades ago adds up to just 4% of the cosmic recipe and that the universe is made almost entirely of stuff we can't see and know next to nothing about: dark matter and dark energy.

In 1941 we observed the heavens only in visible light, whereas today we record cosmic radiation across the electromagnetic spectrum and are on the threshold of detecting gravitational waves. We once had to content ourselves with views from Earth's surface, but now we send telescopes into space and dispatch robots to the far reaches of the solar system.

For most of *S&T*'s history the world's largest optical telescope was the 5-meter Hale reflector at Palomar Observatory. Today more than a dozen 8- and 10-meter reflectors dot mountaintops worldwide, and work is under way on 30- and 40-meter behemoths. With adaptive-optics, modern telescopes produce images of breathtaking resolution and clarity.

The transformation of amateur astronomy has been no less remarkable. If you wanted a telescope in 1941, you made one yourself or settled for a small "department-store" refractor. Now the diversity of high-quality, affordable commercial telescopes is astounding. Today's hobbyists have at their disposal advanced technology that many professionals lacked not so long ago, including GPS-enabled "Go To" telescopes, CCD cameras and spectrographs, autoguiders, and telescope-control and image-processing software.

Publishing has changed too over *S&T's* 70 years, mostly in the last 10. For a while I worried that the internet would put *S&T* out of business. Now I'm more optimistic, thanks mainly to the rise of e-readers and tablet computers and consumers' willingness to pay for books, magazines, and newspapers delivered via those devices. *S&T* may not be rolling off printing presses by its 80th birthday, but I'm confident that it will still be here, chronicling our ever-evolving cosmic perspective and writing the next chapters in the living history of astronomy for a new generation. ✦

__Rick Fienberg__ served as S&T*'s editor in chief from 2001 to 2008. He is now the American Astronomical Society's press officer and education and outreach coordinator.*

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